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FINAL REPORT
1969 ALEUTIAN ISLANDS EXPERIMENT
PROJECT MILROW

SERVICES GROUP

TEXAS INSTRUMENTS
SERVICES GROUP

alex va 22313

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ARPA Order 1498
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FINAL REPORT
1969 ALEUTIAN ISLANDS EXPERIMENT
PROJECT MILROW

28 April 1970

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We wish to thank the AEC Site Manager and other Amchitka-based AEC personnel for their assistance in the program.

Evaluations and data from the land network of stations operated by the Coast and Geodetic Survey of the Environmental Science Services Administration are preliminary data provided to assist in the analysis performed. Final evaluation of these data will be separately reported by the Coast and Geodetic Survey, who may modify information included in this report.

LIST OF ACRONYMS AND ABBREVIATIONS

ADF	Automatic Direction Finder
AEC	Atomic Energy Commission
AFTAC	Air Force Technical Applications Center
GCT	Greenwich Civil Time
OBS	Ocean-Bottom Seismograph
P Wave	Pure Compressional Wave
S Wave	Pure Shear Wave
SSB	Single Sideband
USC&GS	U.S. Coast and Geodetic Survey
USGS	United States Geological Survey

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SECTION I
INTRODUCTION AND SUMMARY

The VELA Seismological Center, upon request from the Advanced Research Projects Agency of the Department of Defense, participated in Project MILROW, an underground nuclear explosion (~ 1000 kt) triggered on 2 October 1969 at 2206Z on Amchitka Island in the Aleutian Chain. Texas Instruments Incorporated was selected to install, operate, and analyze data from a network of Ocean-Bottom Seismograph (OBS) units deployed in waters surrounding Amchitka Island for approximately a 3-week period. The objectives of this program were to record aftershock activity possibly associated with MILROW and to improve epicenter locations of such seismic activity which might occur in the recording period 25 September to 16 October 1969.

An OBS unit-deployment pattern was designed to supplement the geographic coverage provided by a land network of seismic instruments established by the U.S. Coast and Geodetic Survey on Amchitka and outlying islands. Previous signal and noise measurements in the vicinity[1,2] using OBS units suggested that, for probable MILROW-induced events, the detection range would deteriorate rapidly beyond about 50 km. It was decided that 10 OBS units would provide the supplemental coverage desired.

Equipment preparation and ship selection were initiated immediately after receipt of a firm commitment that the OBS operation was to be conducted. From 15 to 31 August 1969, 14 OBS units and all associated auxiliary equipment were tested and repaired as required. After surveying the available vessels, the M/V SEA SCOPE was chartered for use during field operations. Ship rigging was performed in Santa Barbara, California, between 29 August and 5 September. A 12-1/2-ton crane used for launch and recovery was welded to the aft deck, and a "track" system to facilitate storing and moving the OBS units was installed in the cargo hold. The shakedown cruise was conducted off Santa Barbara from 6 to 8 September. Six OBS units were launched and recovered, and most of the auxiliary equipment was tested.

Initial thinking indicated that the OBS array should be deployed about 7 days before the scheduled MILROW shot time and that a postshot recording period of 2 weeks would be desirable. An extensive operational analysis revealed that some units in the array should be deployed as late as practical prior to shot time in order to provide maximum time for potential shot delays and yet obtain optimum record-time capacity on all units. Consequently, array deployment, illustrated in Figure I-1, began on 25 September 1969 and was completed on 30 September 1969. Recovery operations were conducted between 16 October and 1 November; seven units were recovered by sonar recall, and one unit was recovered by backup-clock release.

Originally, three major data-processing goals were specified:

- Prepare film seismograms of all recorded data and analyze the seismograms for signal arrivals
- Measure rates of occurrence of seismic activity during the recording interval
- Use the OBS and USC&GS networks data to determine hypocenter locations for associated events within a 50-km radius of MILROW

Preparation of the film seismograms was a straightforward tape-playback operation. Film-record analysis was performed by a staff of film analysts over a period of approximately 10 weeks. This phase of the work eventually led to the preparation of a list containing associated* events of potential interest.

*Associated events are those signals which correlate by time of arrival at two or more instruments in the combined OBS and USC&GS networks.

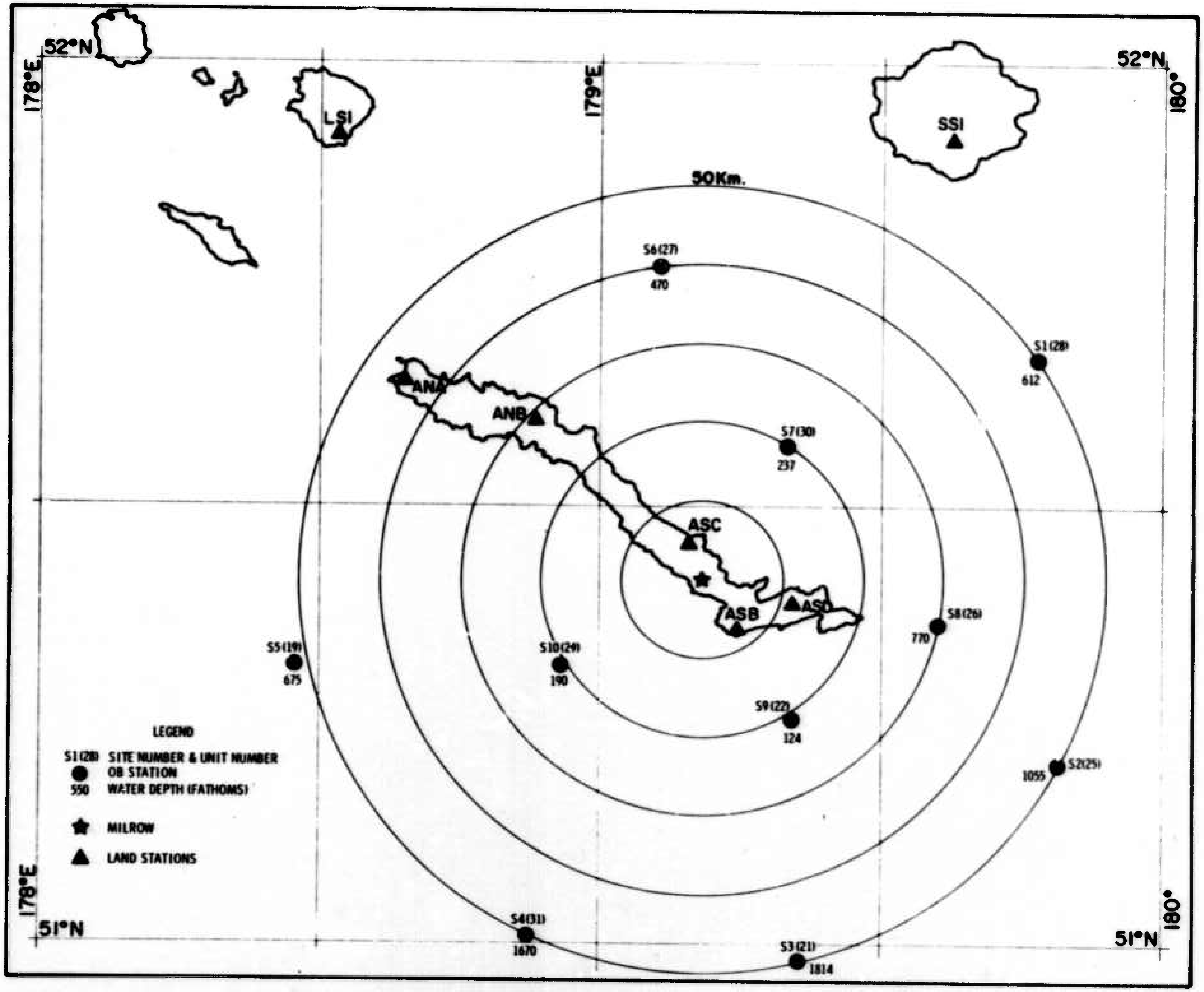

Figure I-1. OBS Deployment Pattern

Due to electronic failure of several units in the array, the distribution and duration of the recorded OBS data fell short of expectation; data for all analyses were derived from units S03, S05, S06, and S08 only. Therefore, it was not feasible to determine from these data alone the rates of occurrence of seismic activity which would be statistically significant or which would materially change the results obtained by the USC&GS in their analysis efforts. No further mention of this original analysis objective is made in this report. However, the raw data, as described later, will be supplied to project headquarters for archiving and possible future use.

The most significant work to be reported here is the evolution and final results of a hypocenter-calculation sequence of data processing. This process, chronicled in this report, begins with analysis of the film seismograms and continues through development of a crustal model combined with a hypocenter-calculation program which permits an iterative solution of traveltime equations leading to hypocenter location.

Approximately 2200 OBS unit-hours of data were analyzed for seismic activity. About 4500 signals were timed, leading to over 250 associated events during the recording period. Of the 250 associated events, 140 were selected for processing through the hypocenter program. Events were selected on the basis of their having a minimum of six recorded P or S phases and estimated epicenters within approximately 150 km of MILROW.

Results of the 140 hypocenter calculations are summarized as follows:

- 81 events produced a convergent solution
- 9 events were near convergence; a solution for these events probably could be obtained by relaxing the constraint on the criteria for solution

- 13 events were out of range of the process (i.e., the distance was greater than 180 km from any one observing station or the focal depth exceeded the maximum allowable depth of 188 km)
- 37 events did not produce convergent solutions due to timing inconsistencies in the signal arrivals, a condition probably resulting from poor signal-to-noise ratios on one or more instruments or from failure to identify the arrivals properly (e.g., P to S conversion classified as pure P or pure S)

Equipment refurbishment was accomplished in Dallas, Texas. Each OBS unit was thoroughly tested before being placed in storage. Every effort was made to insure that all equipment could be placed in field operation with a minimum of lead time.

Particular attention was given to failure analysis, equipment evaluation, and recommendations for equipment improvement. As a result of this effort, it is felt that the percentage of units recovered and the amount of data recorded could be significantly increased through a moderate engineering development program.

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SECTION II
DATA ANALYSIS

2.1 GENERAL

Analysis of the Project MILROW OBS data developed along two broad fronts.

The first effort was systematic analysis of all film seismograms to discern all phase arrivals at each unit. Results of this procedure were tabulated in a list of arrival times stated relative to individual unit clocking. This list of times was subsequently corrected to Greenwich Civil Time (GCT). Using these times and similar event times provided by the USC&GS for the land network, a list of associated events was formed and computer-processed to produce a working document called an earthquake bulletin. Throughout the remainder of the analysis, all events which were subjected to further processing came from this list. Details of the procedures just highlighted are described later in this section.

The second major effort concerned the development of a hypocenter-calculation capability. Two aspects of this development were initiated early in the program: a computer program to calculate hypocenters was written and, coincidental with the progamming effort, a crustal velocity model for local events occurring in the vicinity of MILROW was derived. Ultimately, given the velocity model and unit arrival-time inputs, the program was used to calculate hypocenters for relevant events. Model determination is discussed in subsection 2.3; hypocenter calculation is discussed in subsection 2.4.

2.2 FILM SEISMOGRAM ANALYSIS

All data recorded on magnetic tape were transcribed on 16-mm film for record analysis. Figure II-1 is an example showing the final 40 sec of 1 min of a film seismogram. The trace grouping is pressure (P), vertical motion (V), horizontal-1 motion (H_1), and horizontal-2 motion (H_2). Tape-recorder channel assignments are shown on the left-hand side.

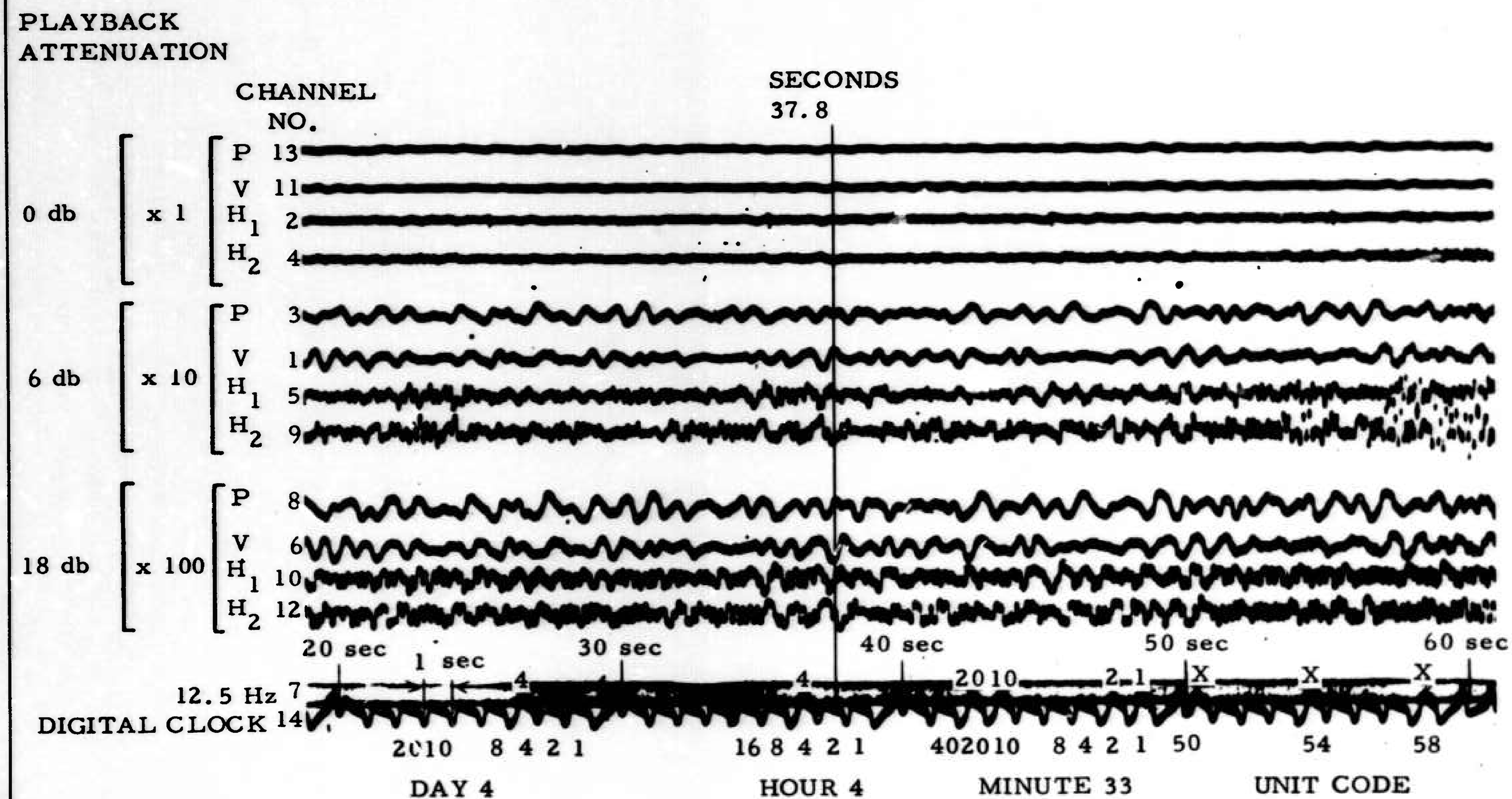


Figure II-1. Sample Film Record

Proceeding vertically down the film, each 4-trace grouping increases in gain. X10 and X100 symbolically denote split levels of recording. X10, for example, indicates a 20-db gain over the X1-level trace grouping. The absolute gain for a given measurement channel is determined by the operating gain used in the field. The operating gains in db for the units analyzed are as follows:

Station	Unit	P	V	H_1	H_2
3	21	-18	-24	-24	-24
5	19	-18	-24	-24	-24
6	27	-24	-30	-30	-30
8	26	-18	-24	-24	-24

During transcription, there was no frequency filtering, but the X10 and X100 trace groups were attenuated 6 db and 18 db, respectively, to avoid trace-overlapping on film. The X100 channel is rarely used because, except for very low-level events in a very quiet background, the trace is usually overmodulated causing severe distortion.

The lowest trace in Figure II-1 is the timing channel. The start of each second is characterized by the downward excursion of the timing channel; 10-sec marks occur at the downward excursion between twin-peak pulses approximately 0.3 sec apart. The minute mark is at the downward excursion of the first of two pulses, the second of which is a twin-peak pulse. In the illustration, 20-, 30-, 40-, and 50-sec marks are indicated; the minute mark is identified by 60 sec.

The timing trace is coded during each minute to give the day (in the interval of 20 to 30 sec), the hour (in the interval of 30 to 40 sec), the minute (in the interval of 40 to 50 sec), and the unit clock-code identification (in the interval of 50 to 60 sec). The time code is a modified binary arrangement yielding the desired number when individual pulse-position weights are added. The weight is added only if the pulse is positive. In Figure II-1, the values are written below the second marks. The time indicated by the vertical line in the illustration is day 4, hour 4, minute 33, and second 37.8. From the table of unit clock codes (Table II-1), the 50-, 54-, and 58-sec pulses indicate the unit to be 19.

Table II-1

UNIT CLOCK-CODE ASSIGNMENTS

Station	Unit	Clock	Station Clock Code
S03	21	21	52, 56
S05	19	19	50, 54, 58
S06	27	27	52, 53, 56, 57
S08	26	1	51

2.2.1 DATA QUALITY. Of the 10 OBS units deployed, eight were recovered. Table II-2 briefly describes the data quality as recorded by each unit. An extensive engineering evaluation of all system failures is included in Section III of this report.

Table II-2

DATA DESCRIPTION

Unit	Description
S01	Not recovered
S02	No data; power failure
S03	Data intermittently useful. Digital clock is readable 73 percent of the time. Recorder amplitudes fluctuate, making reference to ground motion impossible
S04	Not recovered
S05	Data quality generally excellent. Background noise was 1 to 3 Hz
S06	Data quality good. Periods of high-amplitude background noise occur. Amplitude on the vertical component appeared abnormally low. Background noise was 1 to 5 Hz
S07	Data not useful for event association due to digital-clock malfunction. Trace amplitudes fluctuate, making reference to ground motion impossible
S08	Data quality good. Periods of high-amplitude background noise occur. Pressure channel shows large noise fluctuations. Normal strong background noise is 1 Hz
S09	No data; recorder malfunctioned
S10	No data; recorder malfunctioned

2.2.2 TIMING CORRECTIONS. Timing corrections due to digital-clock drift and/or displacement of the tape-recorder heads were determined. Head misalignments can occur when the recording heads are skewed with respect to the direction of tape movement or when the two head banks are incorrectly spaced. In either case, the result is an apparent time difference from channel to channel for an event. Corrections for head misalignment were determined by using either the amplifier shutoff pulse or the daily calibration pulse. All channels were referenced to channel 12. It was assumed that no correction was required between channel 12 and the clock channel (14) — a reasonable assumption inasmuch as the two heads were physically close together; this assumption was necessary because the amplifier shutoff pulse was not recorded on channel 14.

Figure II-2 is an example of head misalignment due to the recording heads being skewed; note the time differences between the amplifier shutoff pulse as recorded on each channel. In this example, the time difference between the pulse on channels 2 and 13 (vertical lines) shows a relative displacement of 0.3 sec.

Table II-3 lists the head-misalignment corrections for each unit; the maximum correction for any channel was 0.4 sec.

At the time of prelaunch checkout, the digital clock of the OBS unit was reset and referenced to GCT by a time-code generator traceable to WWV. Upon recovery, the reference process was repeated. Digital-clock drift for each unit was determined by comparing the prelaunch and recovery references to GCT. Corrections for clock drift were made with the assumption that the drift was linear over the recording period. Table II-3 also lists the clock drift for each unit; individual clock drifts ranged from 0.7 to -1.0 sec.

Figure II-2. Playback of Amplifier-Off Pulse Showing Tape Recorder Head Displacement

Table II-3

RESET TIMES, CLOCK DRIFTS, AND CHANNEL CORRECTIONS

Station	Unit	Corrected Reset Time (GCT)				Drift End Times				Clock Drift (sec)
		Day	Hr	Min	Sec	Day	Hr	Min	Sec	
3	21	29	20	07	16.6	17	04	19	16	0.1
5	19	27	05	00	0.4	17	13	43	00	-1.0
6	27	25	08	28	0.2	18	22	20	00	0.7
8	26	25	22	42	0.4	16	20	26	00	-0.4

Station	Channel Head-Misalignment Corrections (sec)										
	1	2	3	4	5	6	7	8	9	10	11
3	0.30	0.30	0.20	0.20	0.30	0.0	0.0	0.20	0.10	0.30	0.30
5	0.10	0.0	0.10	0.0	0.15	0.0	0.0	0.10	0.0	0.05	0.15
6	0.20	0.10	0.20	0.0	0.20	0.10	0.0	0.20	0.0	0.10	0.10
8	0.30	0.30	0.40	0.30	0.30	0.0	0.0	0.20	0.0	0.35	0.30

EXAMPLE LINEAR DRIFT CORRECTION FOR STATION 5 CHANNEL 3

Raw Time						+	Clock Drift Correction	+	Channel Correction	=	Corrected Time		
Da	Mo	Yr	Hr	Min	Sec		Sec		Sec		Hr	Min	Sec
7	Oct	1969	09	21	30.0	+	-0.5	+	0.1	=	09	21	29.6

2.2.3 FILM ANALYSIS. The film seismograms were examined in a 3-pass operation. Each film strip was analyzed on each pass by a different analyst to achieve quality control and redundancy. Arrival times were picked for all P and S phases discerned. The record-picking process is somewhat subjective when determining signal-onset time. Figure II-3 illustrates the difficulty for a small event near MILROW. The S phase is clearly seen on the horizontal instruments; however, the actual onset is emergent, and its exact time is not clear. The P-arrival identification is even more difficult and shows only as a subtle character change on the vertical-motion and pressure traces. Under these circumstances, best estimates are picked for the P and S arrivals. This estimate is thought to be accurate to 0.1 sec. In many cases, the P arrival cannot be timed at all because of poor signal-to-noise ratios. Should a timing estimate be incorrect by more than a few tenths of a second, a satisfactory hypocenter calculation using this arrival time usually cannot be obtained. If the solution failed to converge or if traveltime residuals seemed too high for a certain station, the data were rechecked. If no timing error was apparent, it was concluded that the arrival was a false association and should not be used in hypocenter calculation. The extent of data rejection is described later.

After the third pass at the film, all arrival times were punched on cards. These cards were processed through a timing-conversion program which applies head-alignment and clock-drift corrections and, using the clock reset times, converts individual unit times to GCT time. An example of the resultant computer printout is shown in Table II-4.

A total of 2200 unit-hours of data was analyzed, yielding 4500 P or S arrivals. Table II-5 shows the number of arrivals from each unit analyzed and the intervals over which the units were operative. The total computer output, of which Table II-4 is an example, and its associated card deck have been supplied separately to project headquarters for archiving.

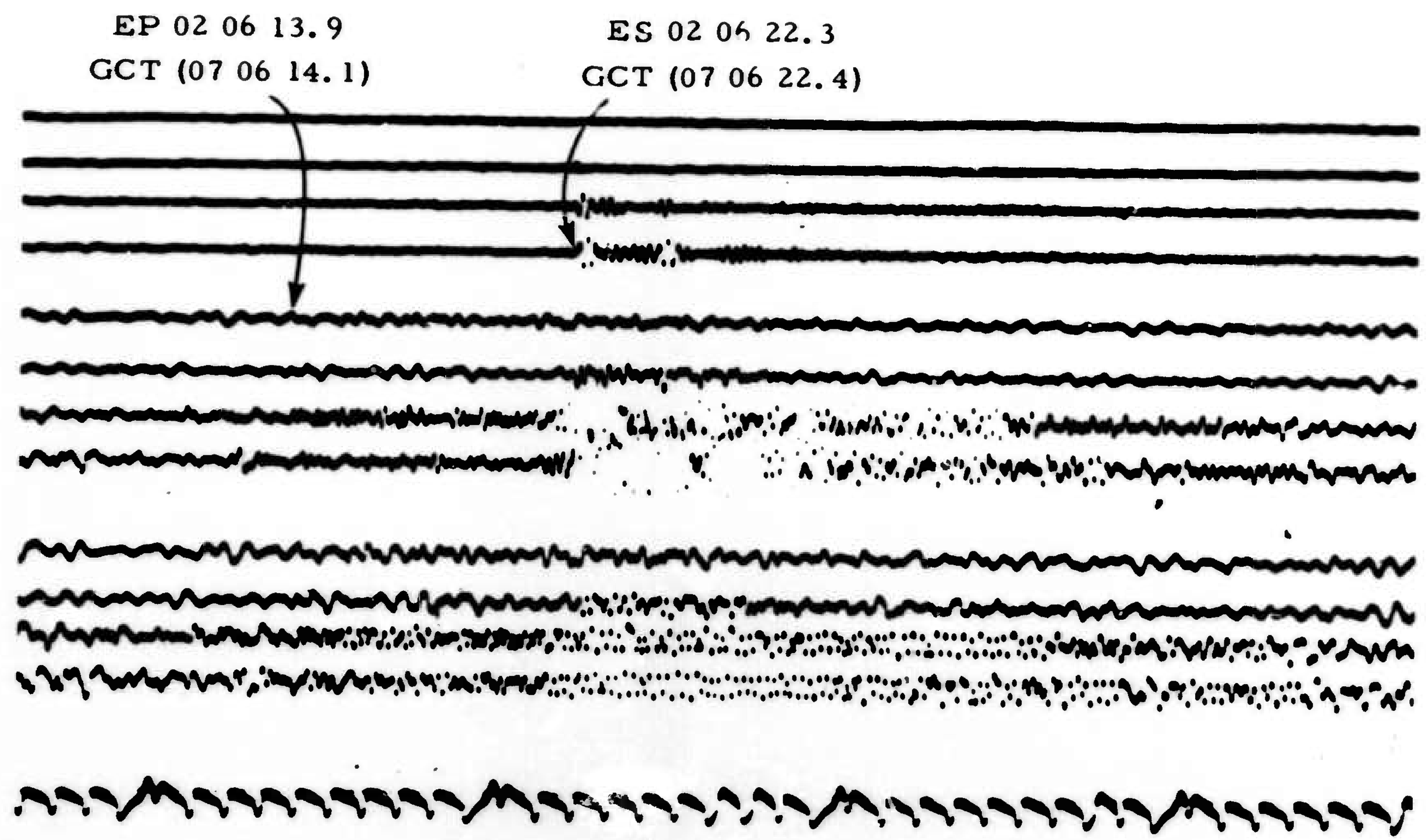


Figure II-3. Example of a Small Event Near MILROW on 3 October 1969

Table II-4

TIME-CORRECTED RAW DATA

EVT* NO.	STA.	PRELIMINARY ANALYSIS DATA DATE		TIME					GCT TIME DATE		TIME			LAST CORR	CORRECTED GCT TIME DATE		TIME		
1	S03	69	1	051503	EP	08PH	1	1	9	30	20	59	69	0	9	30	20	59	69
2	S03	69	1	534270	EP	08PM	5	1	10	1	1	41	436	2	10	1	1	41	438
3	S03	69	3	1741564	EP	08Z?	21	1	10	3	13	49	130	3	10	3	13	49	133
4	S03	69	3	1742 77	ES	08YL	21	2	10	3	13	49	243	2	10	3	13	49	245
5	S03	69	3	1745310+	IP	08ZM	22	1	10	3	13	52	476	3	10	3	13	52	479
6	S03	69	3	1937432	EP	08PM	23	1	10	3	15	44	598	2	10	3	15	45	0
7	S03	69	3	1939477	EP	08PM	24	1	10	3	15	47	43	2	10	3	15	47	45
8	S03	69	3	1939507	ES	08YL	24	2	10	3	15	47	73	2	10	3	15	47	75
9	S03	69	3	2327 47	EP	08PM	25	1	10	3	19	34	213	2	10	3	19	34	215
10	S03	69	4	647294	EP	08ZM	27	1	10	4	2	54	450	3	10	4	2	54	453
11	S03	69	4	916595	IP	08ZM	29	1	10	4	5	24	161	3	10	4	5	24	164
12	S03	69	4	1027 44	ES	08ZM	30	1	10	4	6	34	210	3	10	4	6	34	213
13	S03	69	4	1156173+	IP	08ZM	32	1	10	4	8	3	339	3	10	4	8	3	342
14	S03	69	4	1933369	EP	08ZM	35	1	10	4	15	40	535	3	10	4	15	40	538
15	S03	69	5	2023106	E	08YM	37	1	10	5	16	30	276	2	10	5	16	30	278
16	S03	69	6	052116	EP	08PM	40	1	10	5	20	57	282	2	10	5	20	57	284
17	S03	69	6	344268	IP	08ZM	44	1	10	6	5	51	434	3	10	6	5	51	437
18	S03	69	6	1858290	EP	08ZM	47	1	10	6	15	5	456	0	10	6	15	5	456
19	S03	69	6	1858370	ES	08YM	47	2	10	6	15	5	536	2	10	6	15	5	538
20	S03	69	6	2013594	EP	08ZM	48	1	10	6	16	21	160	3	10	6	16	21	163
21	S03	69	6	2242470	EP	08PM	51	1	10	6	18	50	36	0	10	6	18	50	36
22	S03	69	7	133373	EP	08PM	52	1	10	6	21	40	545	0	10	6	21	40	545
23	S03	69	7	6 3 0	IP	08ZM	55	1	10	7	2	10	166	3	10	7	2	10	169
24	S03	69	7	629323	EP	08PM	56	1	10	7	2	36	489	0	10	7	2	36	489
25	S03	69	7	1241416	E	08AM	59	1	10	7	8	48	582	3	10	7	8	48	585
26	S03	69	7	1724133	EP	08PM	61	1	10	7	13	31	299	0	10	7	13	31	299
27	S03	69	7	2021121	EP	08Z?	62	1	10	7	16	28	287	3	10	7	16	28	290
28	S03	69	7	2241398	E	08PM	63	1	10	7	18	48	564	0	10	7	18	48	564
29	S03	69	8	012 48	E	08PM	64	1	10	7	20	19	214	0	10	7	20	19	214
30	S03	69	8	2 4 40	E(S)	08YM	65	1	10	7	22	11	206	2	10	7	22	11	208
31	S03	69	8	2 5343-	IP	08ZM	66	1	10	7	22	12	509	3	10	7	22	12	512
32	S03	69	8	348417	ES	08YM	68	1	10	7	23	55	583	2	10	7	23	55	585
33	S03	69	8	6 3370	EP	08PM	69	1	10	8	2	10	536	0	10	8	2	10	536
34	S03	69	8	6 3434	ES	08YM	69	2	10	8	2	11	0	2	10	8	2	11	2
35	S03	69	8	1254355	EP	08PS	72	1	10	8	9	1	521	2	10	8	9	1	523
36	S03	69	8	1254389	ES	08YL	72	2	10	8	9	1	555	2	10	8	9	1	557
37	S03	69	8	14 1 9	EP	08ZH	73	1	10	8	10	8	175	0	10	8	10	8	175
38	S03	69	8	14 1105	ES	08YL	73	2	10	8	10	8	271	2	10	8	10	8	273
39	S03	69	8	1533398-	IP	08ZM	75	1	10	8	11	42	564	3	10	8	11	42	567
40	S03	69	9	044567	ES	08XM	78	1	10	8	20	52	133	4	10	8	20	52	137
41	S03	69	9	6 2253	E(P)	08PM	80	1	10	9	2	9	419	1	10	9	2	9	420
42	S03	69	9	6 2333	E(S)	08YM	80	2	10	9	2	9	499	3	10	9	2	9	502
43	S03	69	9	747387	E(S)	08YM	81	1	10	9	3	54	553	3	10	9	3	54	556
44	S03	69	9	1154 91+	IP	08ZM	84	1	10	9	8	1	257	4	10	9	8	1	261
45	S03	69	9	16 4255	E	08ZM	86	1	10	9	12	11	421	4	10	9	12	11	425
46	S03	69	10	147 94	EP	08PM	90	1	10	9	21	54	260	1	10	9	21	54	261
47	S03	69	10	147200	ES	08YM	90	2	10	9	21	54	366	3	10	9	21	54	369
48	S03	69	10	3 4 44	E(P)	08PM	92	1	10	9	23	11	210	1	10	9	23	11	211
49	S03	69	10	3 4190	E(S)	08XS	92	2	10	9	23	11	356	4	10	9	23	11	360
50	S03	69	10	1212247	IP	08PM	97	1	10	10	8	19	413	1	10	10	8	19	414

Table II-5

UNIT SUMMARY

Station	On-Bottom Interval	No. of P and S Arrivals Picked
3	9/30 0700Z – 10/17 0240Z	200
5	9/27 0710Z – 10/17 1230Z	2055
6	9/26 0110Z – 10/18 2135Z	1320
7	9/25 2255Z – 10/19 0015Z	
8	9/26 0600Z – 10/16 1850Z	915

When the master list relating each unit's corrected arrival times to GCT times had been compiled, all data were ordered chronologically by prime arrival. Then, the OBS network data and USC&GS land network data were correlated (time-associated). Isolated phases were discarded at this point. Since preliminary hypocenters had been determined by USC&GS, origin times and hypocenter coordinates from the USC&GS list were used for the associated OBS data which were processed into a preliminary bulletin. An example page from the bulletin is shown in Table II-6. A detailed description of the preliminary bulletin is found in Appendix A. The bulletin itself contains approximately 250 associated events and has been furnished under separate cover. This bulletin formed the data base for hypocenter-location refinement discussed in subsection 2.4.

2.3 MODEL DETERMINATION

A good model of the velocity structure of the local crust is essential to accurate hypocenter calculations using the OBS and USC&GS seismic network data. Once this velocity structure is defined, traveltime tables for P and S waves as a function of distance and focal depth can be calculated for input to the hypocenter-calculation computer program.

Table II-6

SAMPLE PAGE FROM PRELIMINARY BULLETIN

DAY	STA	PHASE	C	TIME	AMP	PER	DIST	AZI
26 SEPT	02 18	07.5	50.96N	178.20W				
				H =	0 KM			
26 SEPT	S6	EP	Z	2 18 40.8			1.88	297
		ES	X	19 4.4			1.88	297
26 SEPT	11 25	17.6	60.12N	152.99W				
				H =	97 KM			
26 SEPT	S8	EP	P	11 29 18.0			17.63	252
26 SEPT	S6	EP	Z	11 29 19.6	161.0	0.4	17.59	254
26 SEPT	19 36	00.5	51.49N	178.54E				
				H =	25 KM			
26 SEPT	S8	EP	P	19 36 4.9			0.67	100
		ES	X	13.8			0.67	100
26 SEPT	S6	EP	P	19 36 16.8			0.46	49
		ES	X	29.3			0.46	49
26 SEPT	20 49	06.0	52.91N	166.99W				
				H =	32 KM			
26 SEPT	S6	EP	P	20 51 10.0			8.59	268
		E	X	17.9			8.59	268
		E	X	25.2			8.59	268
27 SEPT	01 42	51.6	50.86N	179.24W				
				H =	25 KM			
27 SEPT	S8	+IP	Z	1 43 8.6	92.4	0.1	0.90	305
		ES	X	21.3			0.90	305
27 SEPT	S6	EP	Z	1 43 15.7			1.40	313
		E	P	16.8			1.40	313
		E(S)	X	36.4			1.40	313

Data available for inclusion in this analysis consisted of the following:

- Measured traveltimes from the MILROW event recorded at OBS and local land stations
- Measured traveltime data in the vicinity of Amchitka from 5-ton explosions recorded at OBS and land stations during the 1967 OBS Aleutian Islands Experiment
- An interval velocity log from the LONGSHOT borehole

Station information is listed in Table II-7, and explosion information is listed in Table II-8.

Data in the distance range of 0 to 180 km were used to derive the crustal refractors (velocities and depths). Data in the distance range of 185 to 550 km are included in the tables and traveltime plots for the purpose of discussion only and were not used in the model calculations for the following reasons:

- The model derived was for application in the immediate vicinity of Amchitka (about 50-km radius), and crustal information derived from traveltimes to USC&GS stations ADA, SMY, and ATK is representative of the average structure at these station sites
- Accurate Moho depth and velocity across Amchitka was previously determined using arrays of 5-ton calibration explosions and OBS arrays[2,3]

Above the Moho, there remains some uncertainty about the near-regional dip of the shallow refractors. A plane layer model would not be adequate on a 550-km scale; however, inside 180 km, the model chosen is in effect a plane-layered section of the regional model, and each layer represents an average depth. The increased computational difficulty of hypocenter location using a dipping model does not seem justified or consistent with the amount of arrival-time data available for hypocenter location.

Table II-7

STATION INFORMATION

	Station	Location		Elevation — Positive Below Sea Level (km)
		Latitude	Longitude	
1969 OBS MILROW Experiment	S03	50°59'00"N	179°21'30"E	3.317
	S05	51°19'00"N	178°27'30"E	1.234
	S06	51°46'30"N	179°6'30"E	0.859
	S08	51°22'00"N	179°35'42"E	1.408
1967 OBS Experiment plus LONGSHOT and MILROW to Adak	S01	51°25'12"N	178°45'00"E	0.342
	S02	51°16'24"N	178°32'00"E	1.436
	S23	51°41'00"N	179°09'30"E	0.841
	S25	52°02'50"N	179°23'54"E	0.185
	ADA	51°51'48"N	176°39'18"W	-0.1
	ATK	52°12'07"N	174°12'42"W	-0.1
	SMY	52°43'47"N	174°6'33"E	-0.1
CGS Land Net for MILROW	ASB	51°21'38"N	179°14'51"E	-0.031
	ASC	51°27'47"N	179°9'30"E	-0.024
	ANB	51°36'22"N	178°48'41"E	-0.351
	SSI	51°54'52"N	179°37'26"E	-0.265

Table II-8

EXPLOSION INFORMATION

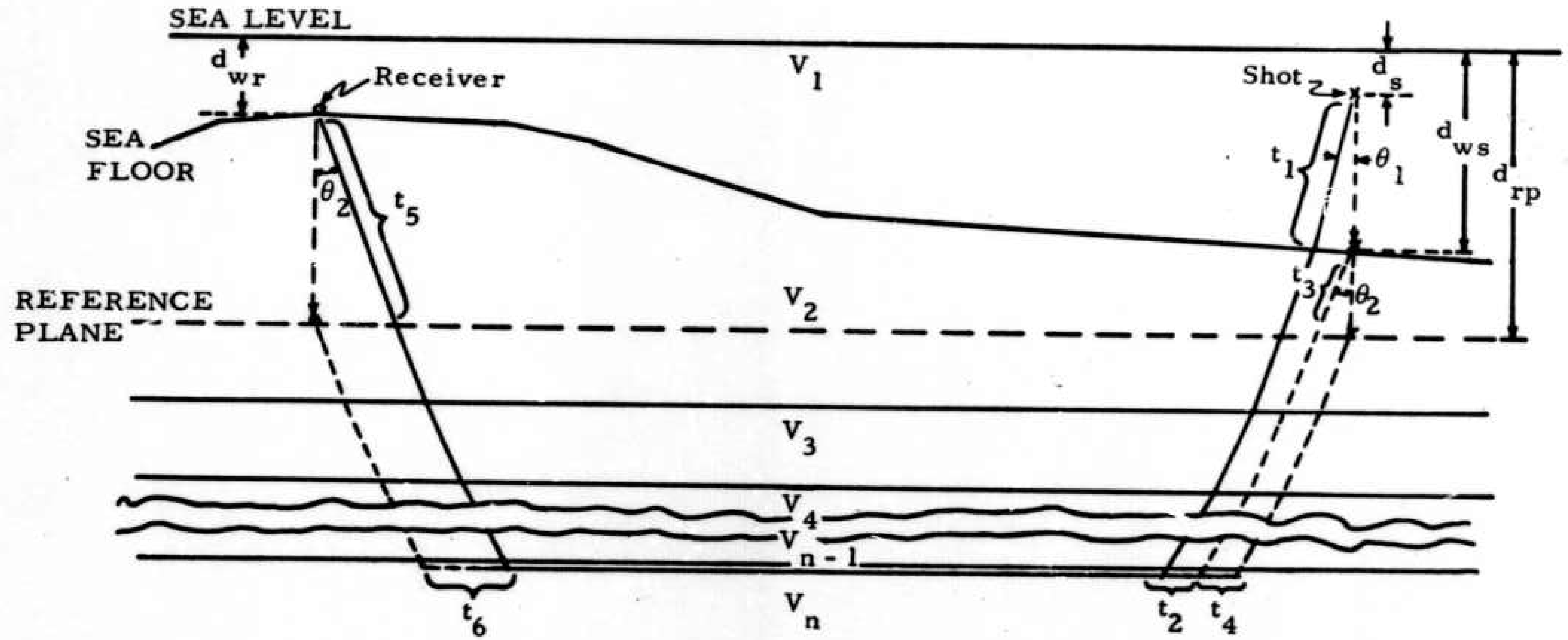
	Event	Event Elevation (ft below sea level)	Date	Detonation Time (GCT)	Location		Water Depth (km)
					Latitude	Longitude	
	MILROW	3862	10/2/69	22:06:00.04	51°25'02"N	179°10'56"E	—
	LONGSHOT	2164	10/29/65	21:00:00.08	51°26'17"N	179°10'57"E	—
1967 OBS Experiment 5-Ton Explosions	E07	621	9/5/68	01:35:02.8	51°38'15"N	179°05'12"E	0.63
	E08	611	9/3/68	22:30:02.1	51°49'30"N	179°20'36"E	0.55
	E24	660	7/20/68	00:32:05.6	51°16'40"N	178°35'24"E	1.39
	E25	664	7/20/68	05:05:05.4	51°10'30"N	178°20'30"E	3.52
	E26	665	7/20/68	07:50:05.5	51°01'36"N	178°10'42"E	3.26

Since the shots and receivers used in this study were not located on the same plane, the data were reduced to a common plane set at sea level for interpretive purposes in the model calculation and subsequent hypocenter calculations. Refractor depths computed from intercept times, as well as hypocenters, are then the depths below sea level. The method of reference-plane correction is shown in Figure II-4. The method reduces the raw traveltimes to traveltimes below a reference plane by stripping off (or adding on when the plane is above the station or shot) the time from shot to reference plane and station to reference plane. The technique was presented in detail in a previous report[2] and is not reiterated here. Two of the shots used in the analysis (MILROW and LONGSHOT) were underground and, of course, have no water path involved in the reference-plane correction scheme. The correction in that case was properly made by simply setting the parameter d_{ws} (Figure II-4) equal to d_s in the program which calculates the corrections, thereby causing a water-path correction of 0 for $-t_1 + t_2$ for those two shots.

All data were processed through the correction program using velocities determined from previous work in the area,[2] and traveltime plots were generated. After examining the plots and running line fits, the data were separated into three groups on the basis of apparent velocity, and the raw data were recycled through the correction program using the measured apparent velocities.

Correction parameters for the three groups are as follows:

	V_1 (km/sec)	V_{2A} (km/sec)	V_{2B} (km/sec)	V_n (km/sec)	RP (km)	DP (km)	V_{RED} (km/sec)
Shallow Pg arrivals	1.5	3.6	5.0	5.2	0.0	-2.0	8.0
Pg arrivals	1.5	3.6	5.0	6.8	0.0	-2.0	8.0
Pn arrivals	1.5	3.6	5.0	8.1	0.0	-2.0	8.0



$$\sin\theta_1 = \frac{V_1}{V_n} \quad \text{and} \quad \sin\theta_2 = \frac{V_2}{V_n}$$

RECEIVER CORRECTION

$$= -t_5 + t_6$$

$$= -\frac{(d_{rp} - d_{wr})}{V_2 \cos\theta_2} + \tan\theta_2 \frac{(d_{rp} - d_{wr})}{V_n}$$

$$= \frac{(d_{wr} - d_{rp})\cos\theta_2}{V_2}$$

SHOT CORRECTION

$$= -t_1 + t_2 - t_3 + t_4$$

$$= -\frac{(d_{ws} - d_s)}{V_1 \cos\theta_1} + \frac{\tan\theta_1 (d_{ws} - d_s)}{V_n} - \frac{(d_{rp} - d_{ws})}{V_2 \cos\theta_2} + \frac{\tan\theta_2 (d_{rp} - d_{ws})}{V_n}$$

$$= \frac{(d_s - d_{ws})\cos\theta_1}{V_1} + \frac{(d_{ws} - d_{rp})\cos\theta_2}{V_2}$$

Figure II-4. Method of Reference-Plane Correction

The correction variables are defined as

V_1 = water velocity

V_{2A} = layer velocity (low)

V_{2B} = layer velocity (high)

V_n = refractor velocity

RP = reference-plane depth

DP = decision-plane depth

V_{RED} = velocity used to compute reduced traveltime t_R, i.e.,

$$t_R = t - \frac{\Delta}{V_{RED}}$$

t = traveltime corrected to RP

Δ = distance in kilometers

CalComp plots of the raw, corrected, and reduced times were made and are presented in Figures II-5 through II-7. Table II-9 gives the raw, corrected, and reduced traveltimes and the distance for each shot/station pair.

Shown in Figure II-7 are velocity lines of 8.1 km/sec fitted through the data recorded at ADA, SMY, and ATK. The velocity line shown at the top of the figure represents the Moho refractor used in the final crustal model. That line passes closely through the ATK data points, indicating comparable average structure at Amchitka and ATK.

The velocity lines through SMY and ADA data points show smaller intercept times which are indicative of a thinner crust or a higher average crustal velocity at those sites, provided that the Moho refractor velocity remains constant over this area.

The Moho refractor velocity and depth used in the final model were taken from a previous study[2] and are applicable in the area of interest, which is roughly a circle of 50-km radius centered on Amchitka Island.

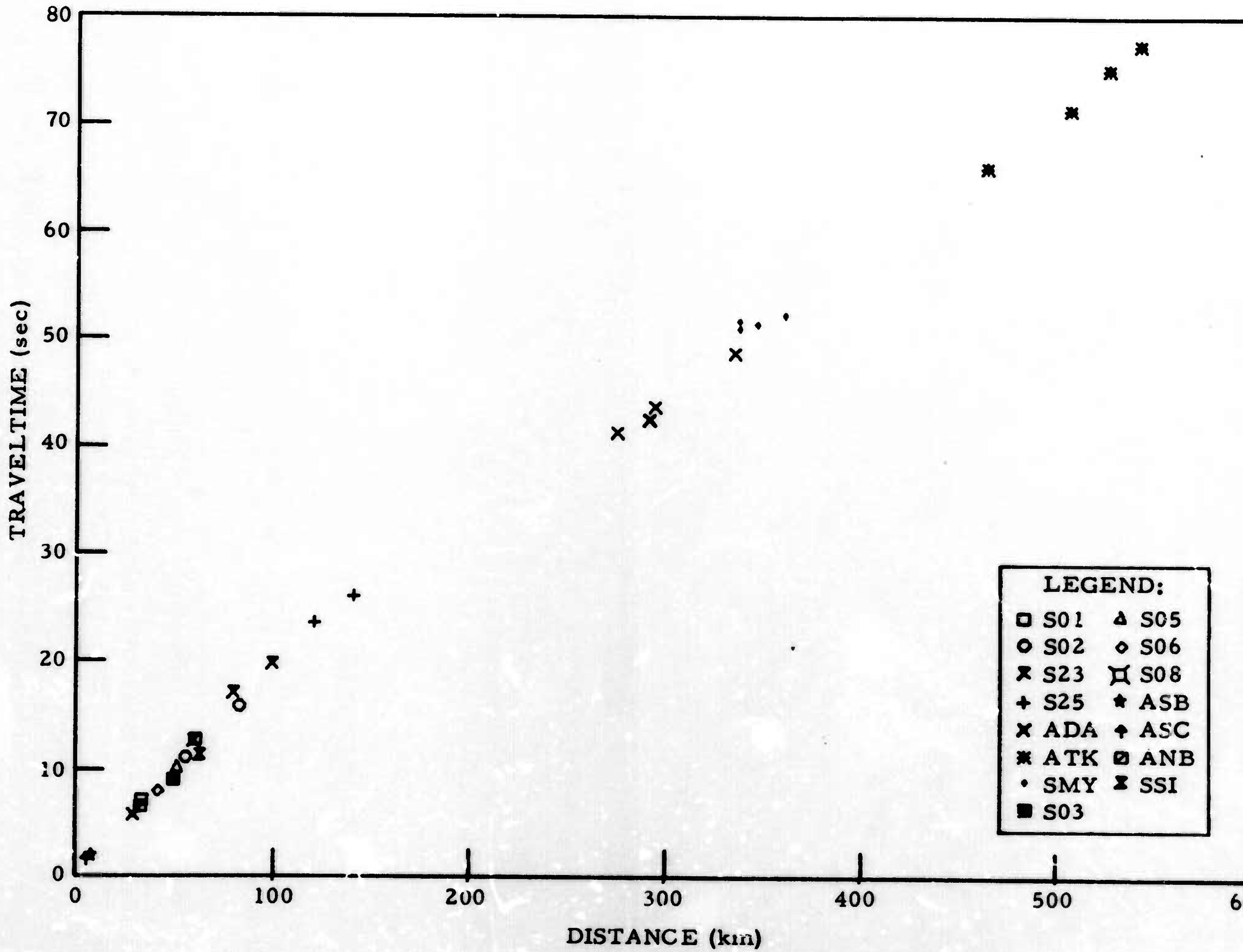


Figure II-5. Raw Traveltimes, All Data

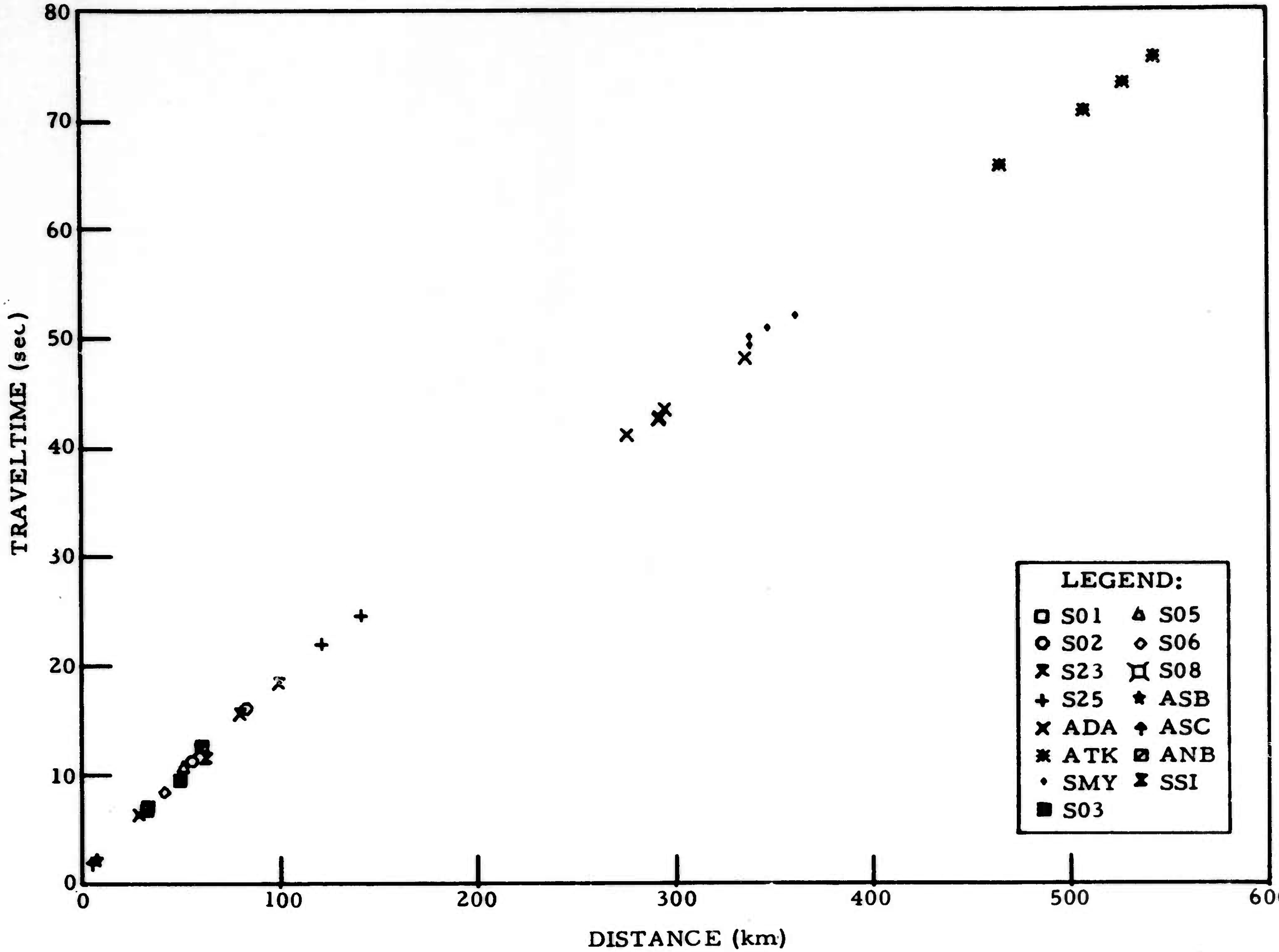


Figure II-6. Corrected Traveltimes, All Data

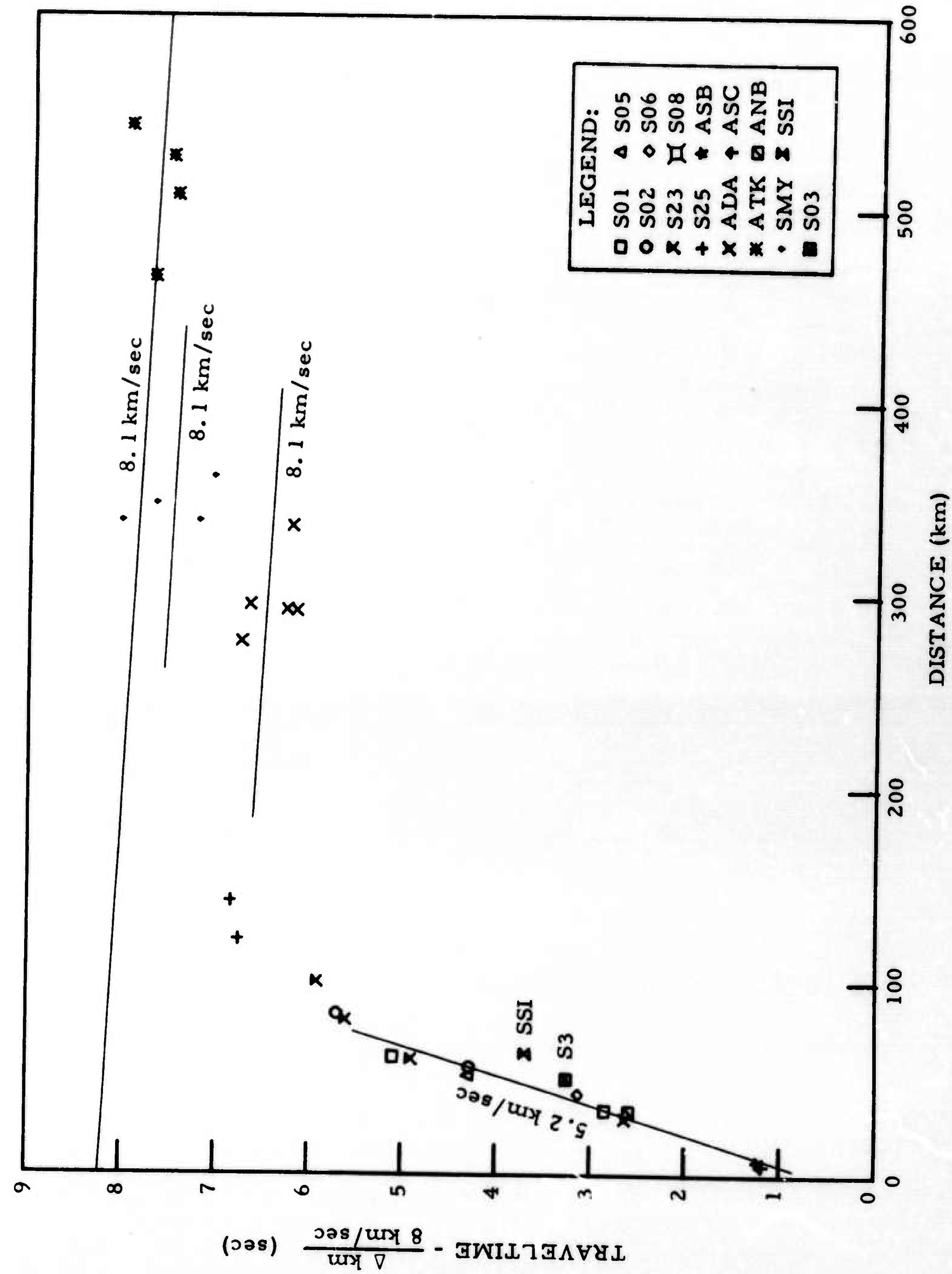


Figure II-7. Reduced Traveltimes, All Data

Table II-9

TRAVELTIME DATA FOR ALL SHOT/STATION PAIRS

Station	Shot	Raw Traveltime (sec)	Corrected Traveltime (sec)	Reduced Traveltime (T_c - Δkm/3.0 km/sec) (sec)	Distance (km)
S03	MILROW	9.06	9.49	3.26	49.82
SSI	MILROW	11.41	11.60	3.70	63.21
ASC	MILROW	1.61	1.85	1.18	5.36
ASB	MILROW	1.96	2.20	1.23	7.77
ANB	MILROW	6.56	6.73	2.58	33.24
S08	MILROW	5.76	6.29	2.63	29.28
S01	E07	7.13	7.04	2.84	33.64
S06	MILROW	7.96	8.38	3.13	41.98
S05	MILROW	10.26	10.75	4.30	51.65
S02	E07	11.13	11.26	4.28	55.88
S23	E24	12.70	12.39	4.89	59.97
S01	E08	12.77	12.71	5.09	60.99
S23	E25	17.10	15.62	5.60	80.17
S02	E08	15.87	16.10	5.69	83.23
S23	E26	19.76	18.41	5.91	100.01
S25	E25	23.60	21.96	6.77	121.57
S25	E26	26.06	24.56	6.85	141.65
ATK	E07	66.03	65.87	7.71	465.27
ATK	E24	71.40	70.94	7.49	507.63
ATK	E25	75.10	73.46	7.54	527.34
ATK	E26	77.36	75.84	7.98	542.92
SMY	E07	52.43	52.27	7.09	361.48
SMY	E24	51.60	51.14	7.70	347.53
SMY	E25	51.20	49.56	7.24	338.52
SMY	E26	51.86	50.34	8.06	338.27
ADA	E24	48.70	48.24	6.23	336.06
ADA	E07	43.73	43.57	6.68	295.17
ADA	LONGSHOT	42.52	42.67	6.17	291.97
ADA	MILROW	42.56	42.84	6.28	292.44
ADA	E08	41.37	41.24	6.76	275.84

Also shown in Figure II-7 is a velocity line of 5.2 km/sec. Two stations, S03, and SSI, deviate from the line and were not included in the least-squares line fit for the shallow Pg refractor. For station S03, the shot depth was about 1.2 km, and the station depth was 3.3 km. The refractor interface was 1.5 km; consequently, the ray path from shot to receiver could not be refracted along that interface and was therefore a direct arrival, as illustrated in Figure II-8. A simple calculation (horizontal distance/raw traveltime) yields a velocity of about 5.5 km/sec, which is consistent with a propagation path almost entirely in the shallow Pg layer of the final model.

The traveltime from MILROW to SSI was 1 sec early in relation to other shot/station pairs with comparable distances. Since the time was not consistent with the other data and without recourse to the recordings, no decision can be made regarding validity of the point. It could represent a simple timing error, or — less probable — a station-location error of 5 km would account for 1 sec of traveltime in the refractor. It could actually indicate a higher velocity in that azimuth; however, additional data in that direction would necessarily have to be obtained to verify that possibility. It is shown later, however, that SSI data yielded consistent results using the derived model for hypocenters both inside and outside the combined land and OBS network. Moreover, examination of the associated events shows that SSI consistently had difficulty — during the recording period at least — recording events in the vicinity of the MILROW site.

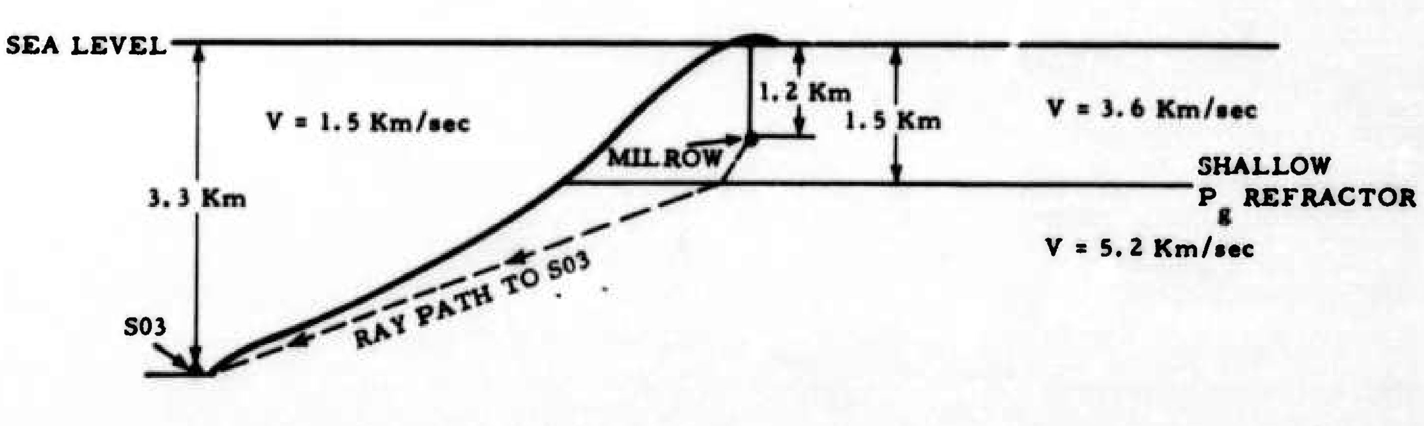


Figure II 8. Diagramatic Ray Path from MILROW to Station S03 (Vertical Scale Exaggerated)

Next, least-square line fits were calculated for the shallow Pg and the Pg refractor. Figures II-9, II-10, and II-11 show raw, corrected, and reduced traveltimes of the data used in the line fits. A comparison of the raw and corrected traveltime plots show the effect of the reference-plane correction in reducing the scatter of the points due to differing receiver elevations and shot depths and the removal of the low-velocity water leg for those shots in water. In addition, the standard deviation of each set of points is reduced. The following are standard deviations of line fits to raw and corrected times for the two sets of points.

Refractor	Raw (sec)	Corrected (sec)
Shallow Pg	0.36	0.21
Pg	0.62	0.14

These line fits were obtained:

- Shallow Pg — slope = 0.1937
  velocity = 5.16 km/sec
  intercept = 0.59 sec
- Pg — slope = 0.1470
  velocity = 6.80 km/sec
  intercept = 3.80 sec

The line fits and points used are shown on the reduced traveltime plot in Figure II-11. Calculation of the depth of the first refracting interface (shallow Pg) requires a knowledge of the layer velocity above the refractor. A published interval velocity log from the LONGSHOT borehole was obtained. The log was integrated, yielding a velocity of 3.4 km/sec which is the average velocity from the surface to a depth of about 0.8 km. Using the velocity gradient of the log, the calculated average velocity from the surface to the MILROW shot depth was about 3.6 km/sec, which was taken as the velocity for the first layer. Next, the model was calculated from the velocities and intercept times using standard refraction methods which assume plane constant-velocity layering.

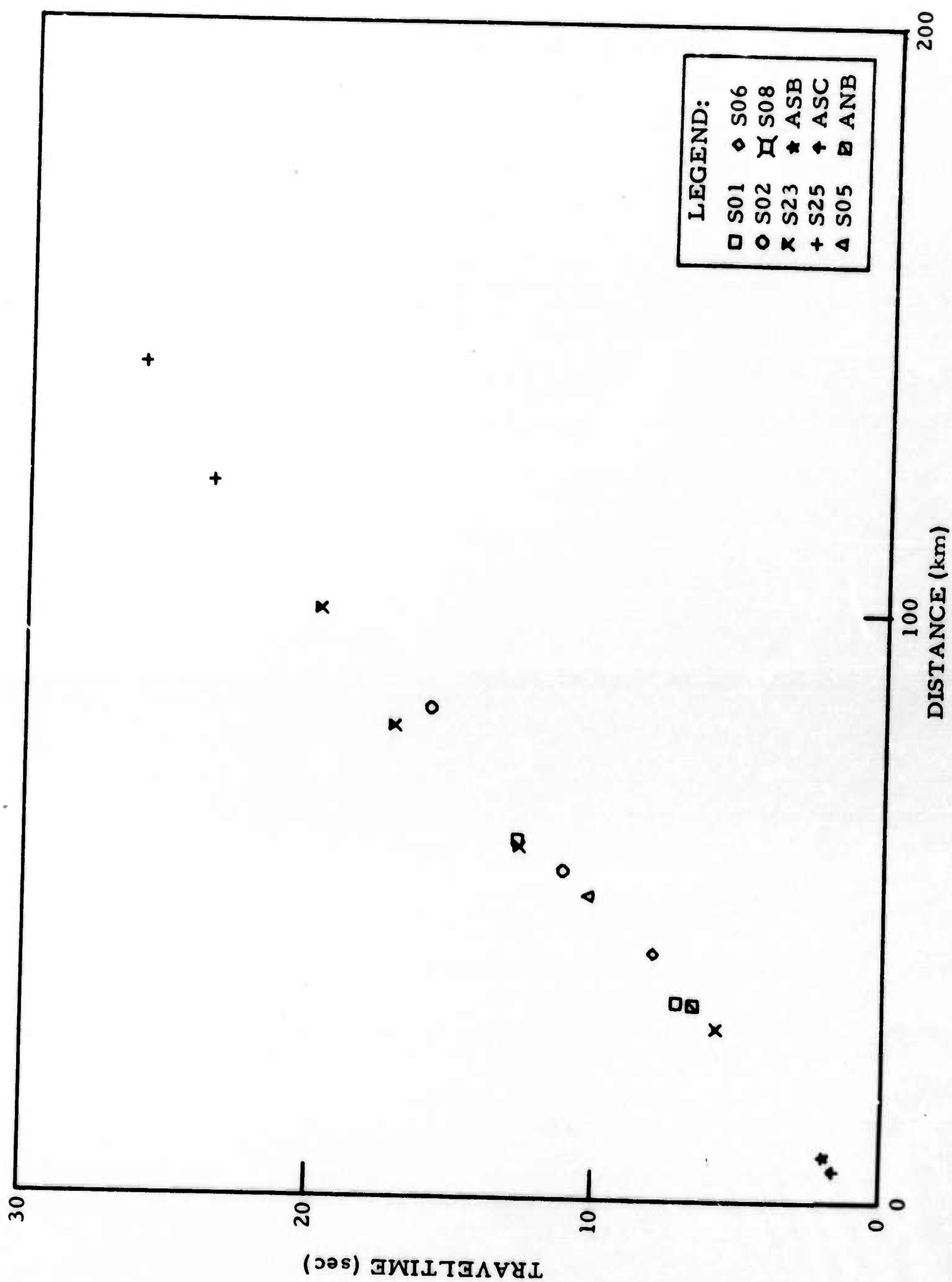


Figure II-9. Raw Traveltimes, Shallow Pg and Pg Refractor

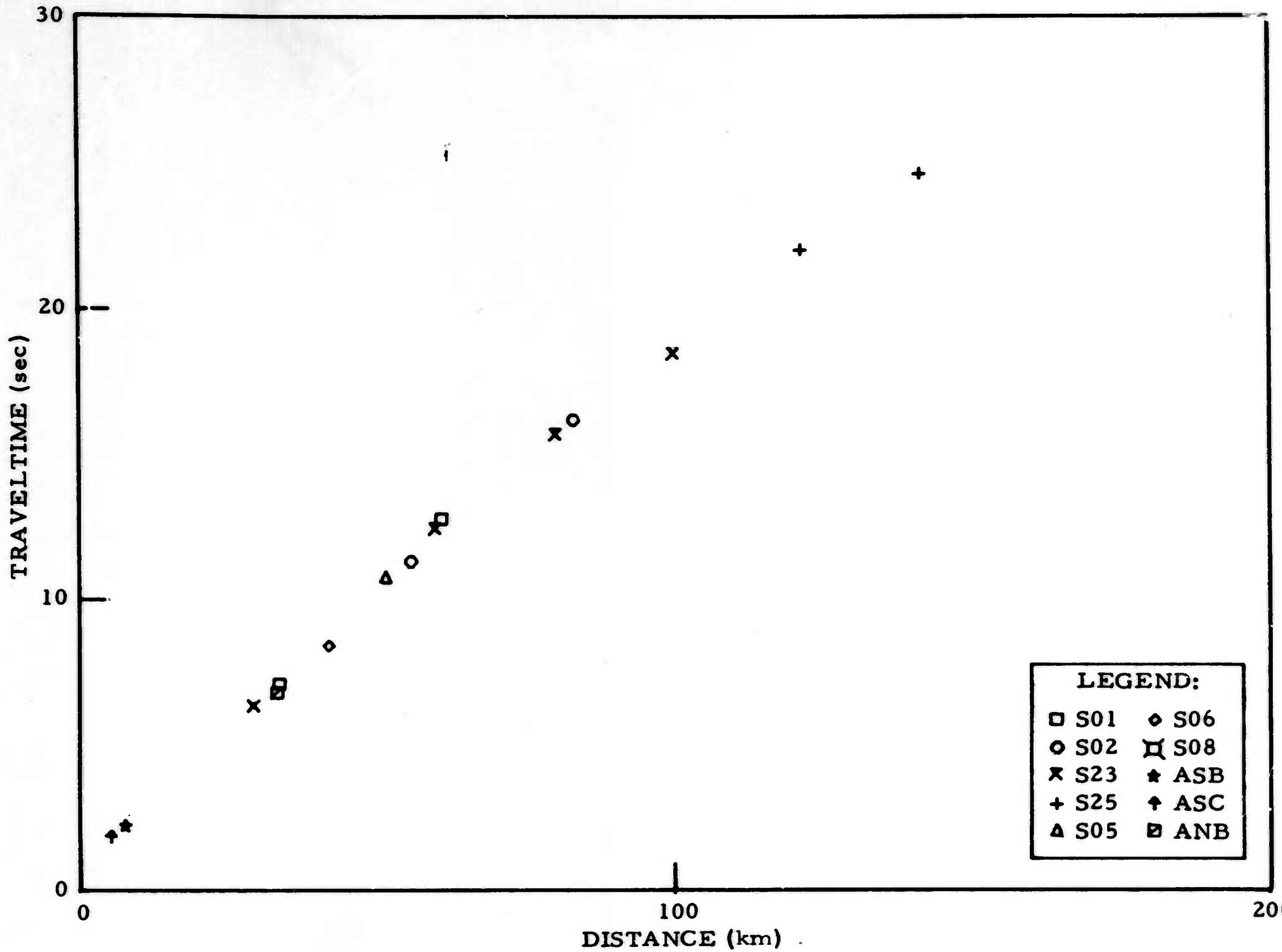


Figure II-10. Corrected Traveltimes, Shallow Pg and Pg Refractor

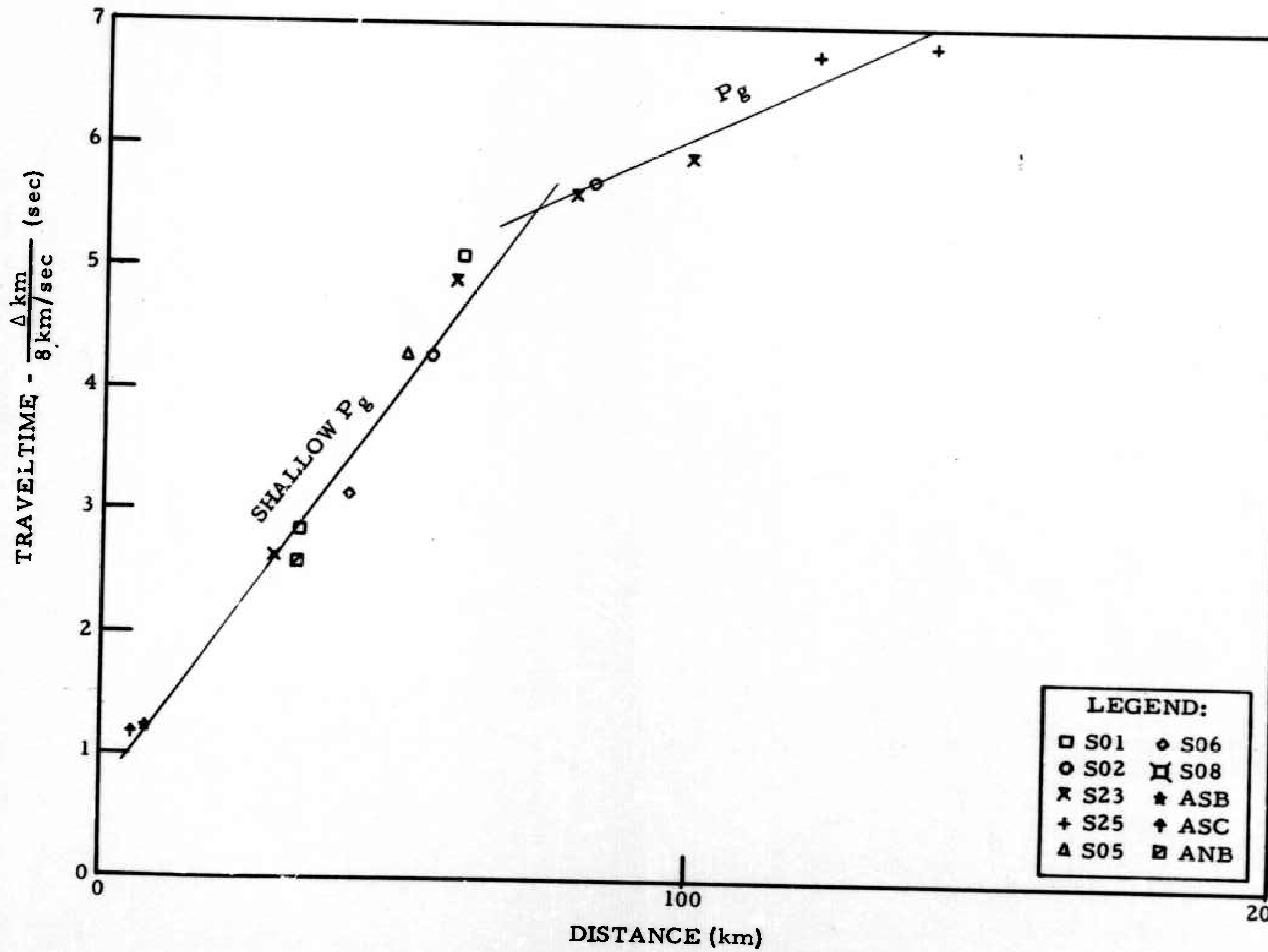


Figure II-11. Reduced Traveltimes, Shallow Pg and Pg Refractor

The Amchitka crustal model is presented in Figure II-12. The S-wave velocities were calculated from P-wave velocities using 0.25 for Poisson's ratio. The model was then input to a program which computes theoretical traveltime curves for direct and refracted P and S waves over a range of horizontal receiver distances and a range of source depths. Each pair of curves representing the first arrival time for a pure P wave (Figure II-13) and a pure S wave (Figure II-14) was calculated for horizontal source/receiver distances of 0 to 180 km in increments of 5 km. A total of 30 pairs was computed for source depths ranging from 0 to 188 km in the following depth increments:

- 0.3-km increments from 0 to 1.5 km
- 2.0-km increments from 2 to 14 km
- 4.0-km increments from 15 to 35 km
- 10.0-km increments from 38 to 68 km
- 20.0-km increments from 68 to 188 km

The 3-dimensional matrix of theoretical traveltimes (horizontal range vs source depth vs wave type) provides the model base for the hypocenter-calculation program which interpolates the sampled traveltime curves in both range and depth as necessary to yield traveltimes at intermediate points.

2.4 HYPOCENTER ANALYSIS

As mentioned earlier, the principal analysis goal of the experiment was to calculate hypocenters for seismic activity within 50 km of MILROW. The film seismogram analyses discussed in subsection 2.2 were fundamental in developing the preliminary bulletin from which to choose events for hypocenter-location refinement. From this preliminary bulletin, all events which were reported by six or more stations were selected for hypocenter-location refinement tests; 140 such events were selected. These data, combined with the derived velocity model (subsection 2.3), were input to a computer program for hypocenter calculation. Ultimately, 81 events were located by the program; 26 of these events were within 7 km of the MILROW site. The following paragraphs describe the procedures used in the hypocenter calculations.

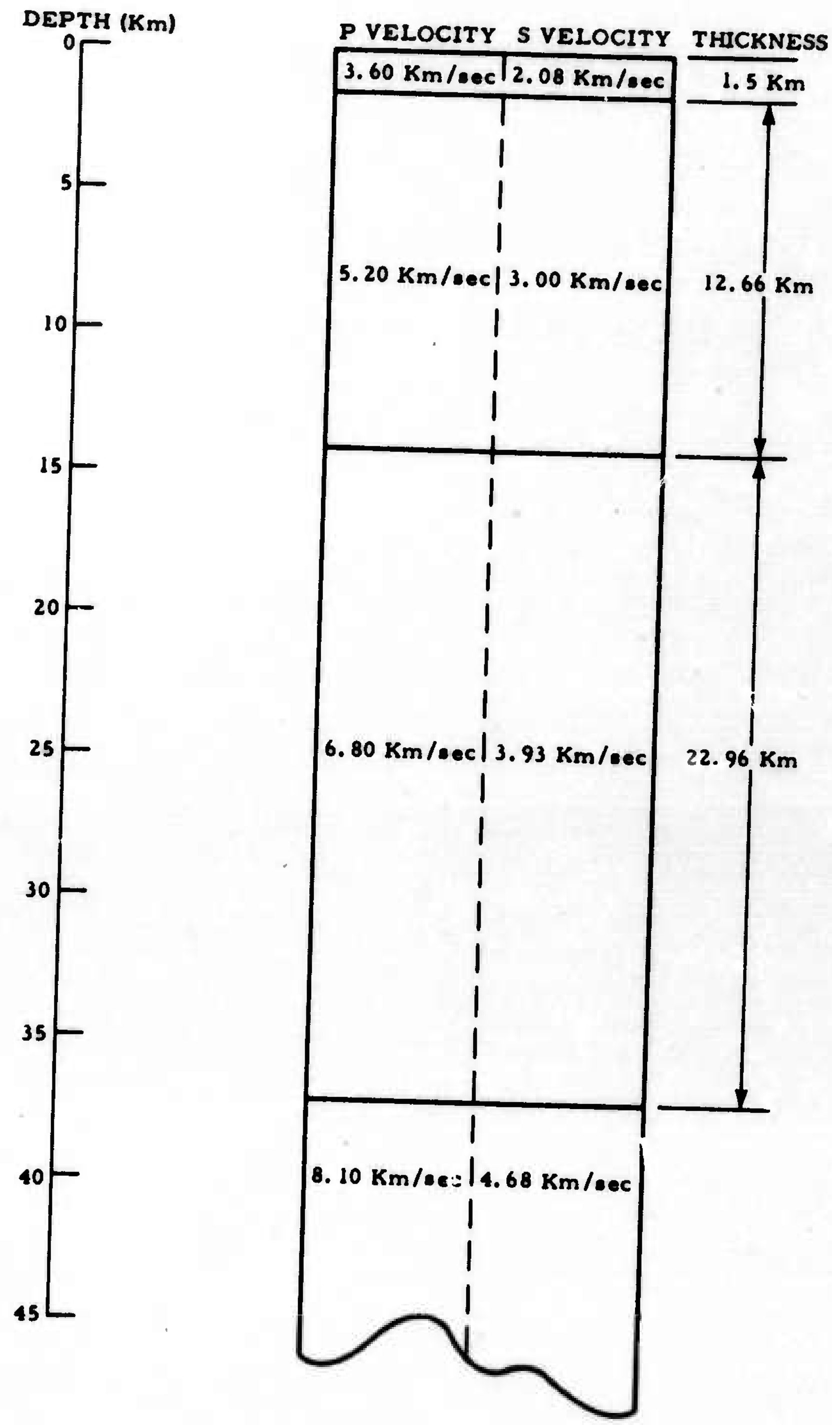
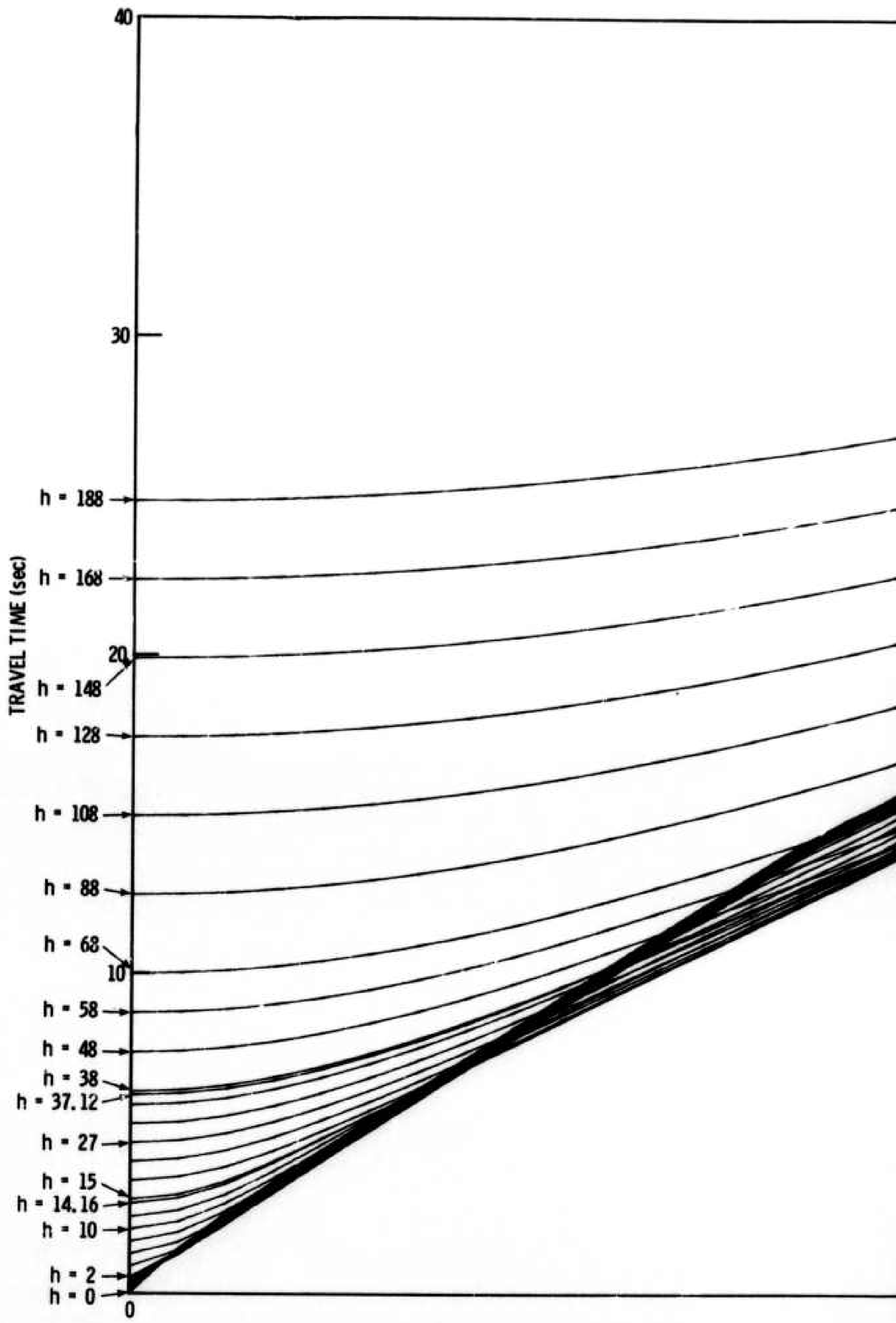


Figure II-12. Amchitka Crustal Model



40
30
20
10
0
TRAVEL TIME (sec)
h = 188
h = 168
h = 148
h = 128
h = 108
h = 88
h = 68
h = 58
h = 48
h = 38
h = 37.12
h = 27
h = 15
h = 14.16
h = 10
h = 2
h = 0

A

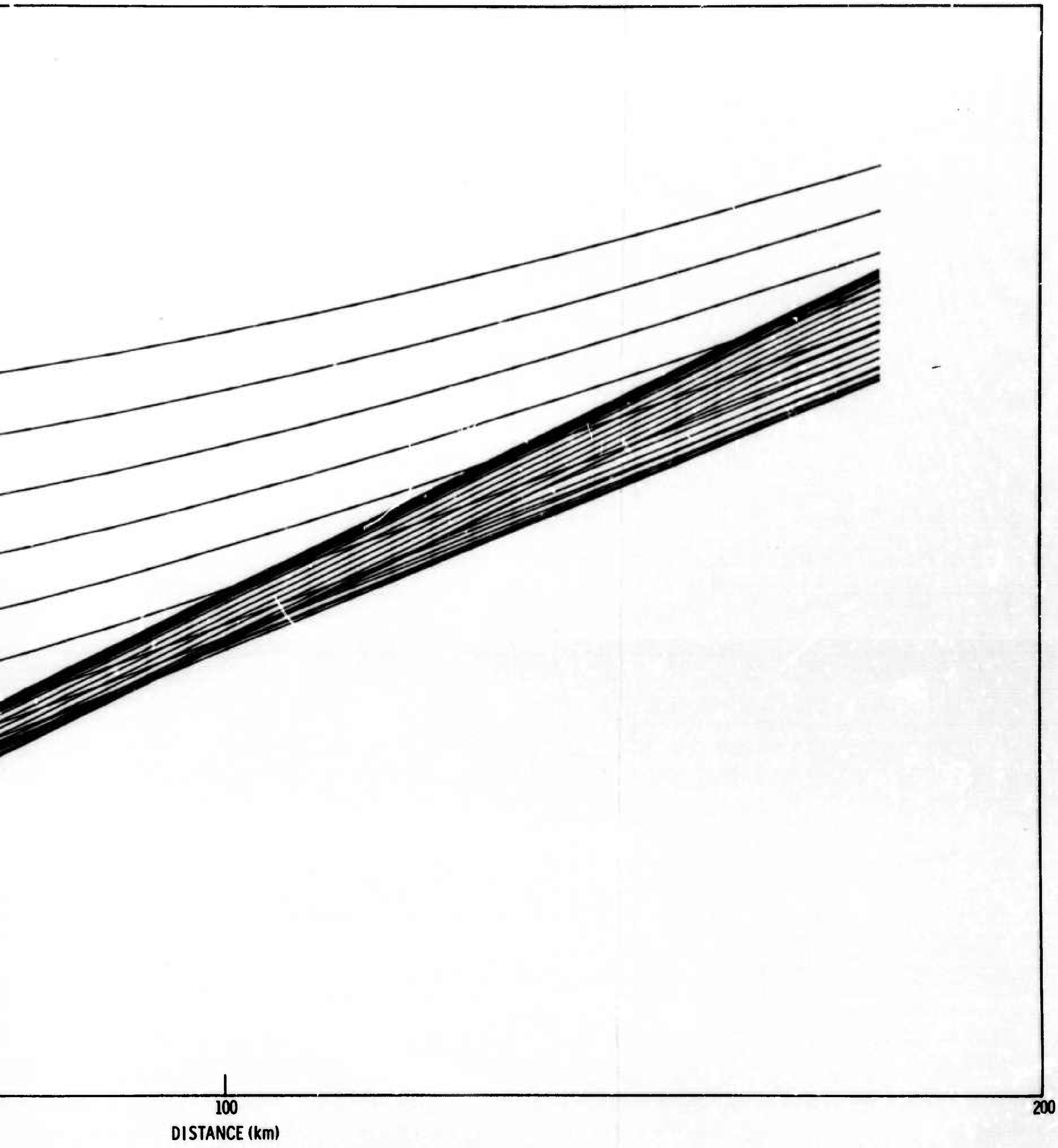
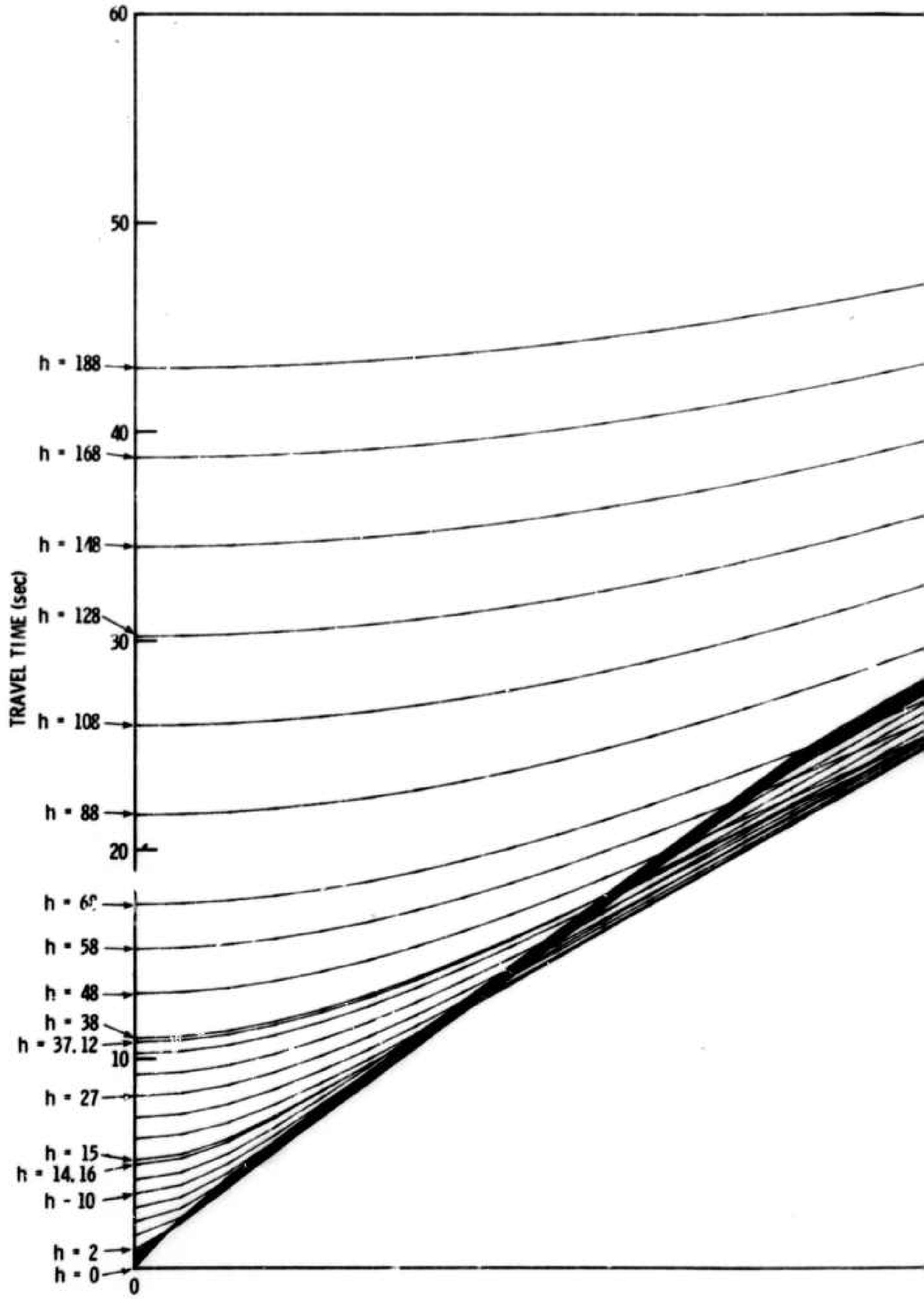


Figure II-13. Theoretical Traveltimes for Amchitka Crustal Model, First-Arrival P Waves

B


60
50
40
30
20
10
0
TRAVEL TIME (sec)
h = 188
h = 168
h = 148
h = 128
h = 108
h = 88
h = 60
h = 58
h = 48
h = 38
h = 37.12
h = 27
h = 15
h = 14.16
h - 10
h = 2
h = 0

A

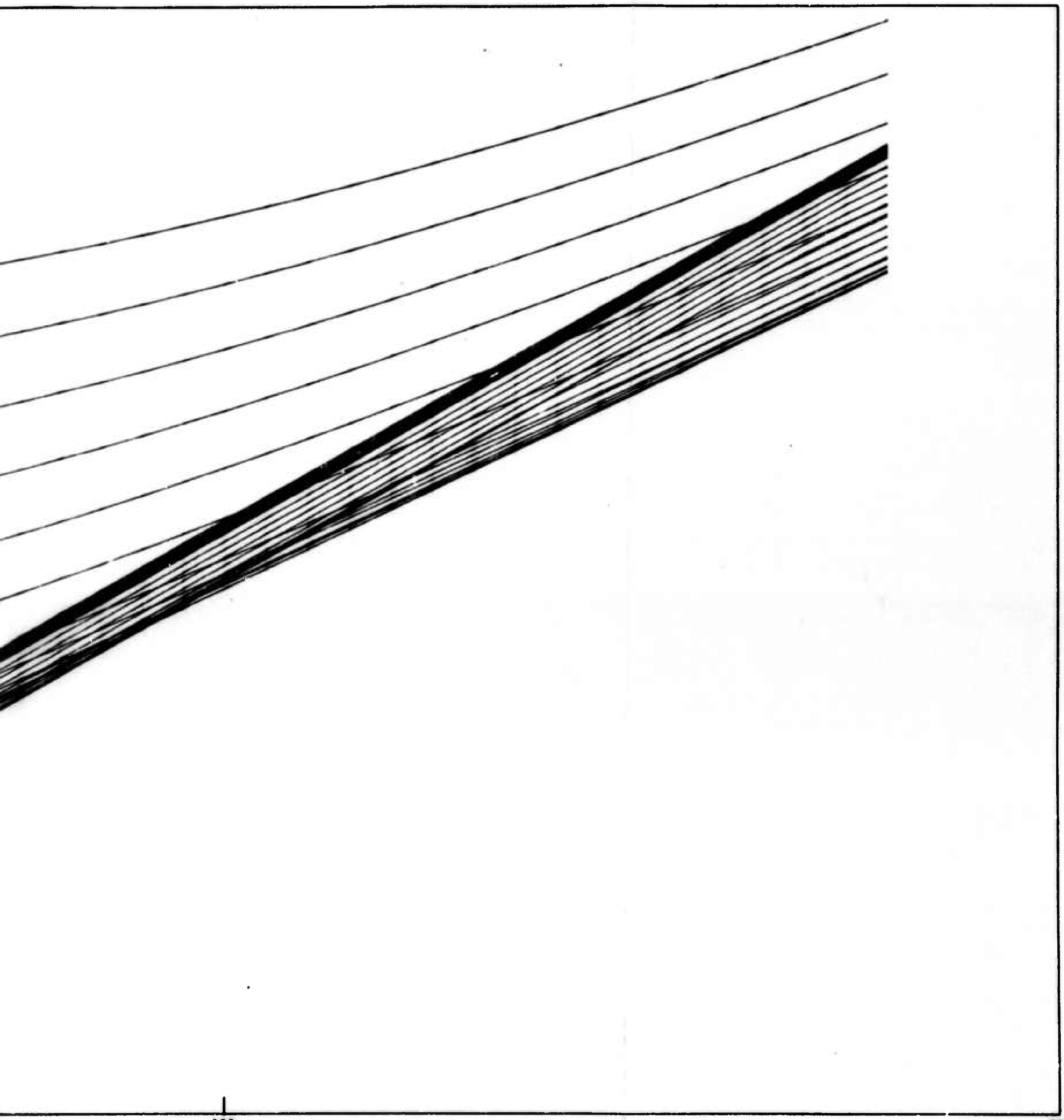


Figure II-14. Theoretical Traveltimes for Amchitka Crustal Model, First-Arrival S Waves

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2.4.1 HYPOCENTER PROGRAM. A hypocenter-calculation program was coded and checked out on the IBM S/360 computer. The program employed an algorithm similar to that used by Flinn.[4] The method is a least-mean-square iterative process using a matrix of traveltime equations for P and S direct arrivals. The program was extended to include refractions of pure P and S arrivals by incorporating the respective theoretical traveltime curves calculated from the crustal model. Iteration in the calculation sequence ceases with an allowable solution when the vector sum of the absolute errors in the X, Y, and Z directions of a rectangular coordinate system is less than 1.0 km and the error in origin time is less than 0.1 sec.

For each iteration, a set of residual times is calculated along with its associated standard deviation. However, the solution from each iteration is based on a least-mean-square distance error. It is noted that, in reaching an allowable solution, the time-residual standard deviation may not monotonically decrease and may not always be the minimum in the iteration that produced solution. This latter condition is caused partially by interpolation in the traveltime tables for specific depths and ranges. Interpolation error is greatest where the traveltime function curves. Where the traveltime function is linear (refraction), the interpolation is accurate to three decimal places. The difference in the final time-residual standard deviation and a standard deviation which might have been smaller for an earlier iteration is always in the second decimal place (hundredths of a second), which is believed insignificant.

Geographic coordinates are input to and output from the program; however, calculations are made after conversion to rectangular coordinates. A range in excess of 180 km begins to involve significant earth-curvature effects, but no calculations are made beyond this range from MILROW. The maximum focal depth permitted is 188 km — a choice based on seismicity in the vicinity of Amchitka.

2.4.2 HYPOCENTER CALCULATIONS. A total of 140 events were input to the hypocenter program for calculations. The input consisted of associated P and S arrivals observed by the four OBS units and seven USC&GS land stations. Unit weight was assigned to all arrivals. Table II-10 shows location and elevation for all stations in the combined network. Figure II-15 is a map of the stations used. Tables II-11 and II-12 give information for the events processed; the following is a summary of the results.

- 81 events produced a convergent solution
- 9 events were near convergence; a solution for these events probably could be obtained by relaxing the constraint on the criteria for solution
- 13 events were out of range (i.e., the distance was greater than 180 km from any one observing station)
- 37 events did not produce convergent solutions due to inconsistencies in the signal arrivals — a condition probably resulting from poor signal-to-noise ratios, failure to identify arrival type correctly, spurious association, or possible network geometry deficiency

Figure II-16 was compiled from Tables II-11 and II-12 and shows the amount of available data (P and S arrivals) from the 10-station network for the 140 events. Only one arrival is available from station ANB (P wave from MILROW), and no MILROW traveltimes were obtained for stations ASD and ANA. In addition, only a few of the 44 associated near-MILROW events were observed by stations ANA, SSI, and S03. Hypocenters were calculated for a total of 81 events in the area; these are charted in Figure II-17 (in pocket).

In the hypocenter calculations for the 81 events which converged to a solution, neither the depth nor the origin time were constrained to obtain a solution.

Table II-10

STATION DATA FOR COMBINED NETWORKS

Station	Latitude	Longitude	Elevation (Positive Below Sea Level) (km)	P Correction (sec)	S Correction (sec)
S03	50°59'0.0"N	179°21'30.0"E	3.317	0.45	0.78
S05	51°19'0.0"N	178°27'30.0"E	1.234	0.29	0.50
S06	51°46'30.0"N	179°6'30.0"E	0.859	0.20	0.35
S08	51°22'0.0"N	179°35'42.0"E	1.408	0.33	0.57
ASB	51°21'38.0"N	179°14'51.0"E	-0.031	-0.01	-0.01
ASC	51°27'47.0"N	179°9'30.0"E	-0.024	-0.01	-0.01
ASD	51°23'26.0"N	179°20'32.0"E	-0.062	-0.02	-0.02
SSI	51°54'52.0"N	179°37'26.0"E	-0.265	-0.06	-0.11
LSI	51°55'11.0"N	178°32'2.0"E	-0.128	-0.03	-0.05
ANA	51°37'34.0"N	178°39'23.0"E	-0.177	-0.04	-0.07
ANB	51°36'22.0"N	178°48'41.0"E	-0.351	-0.08	-0.14

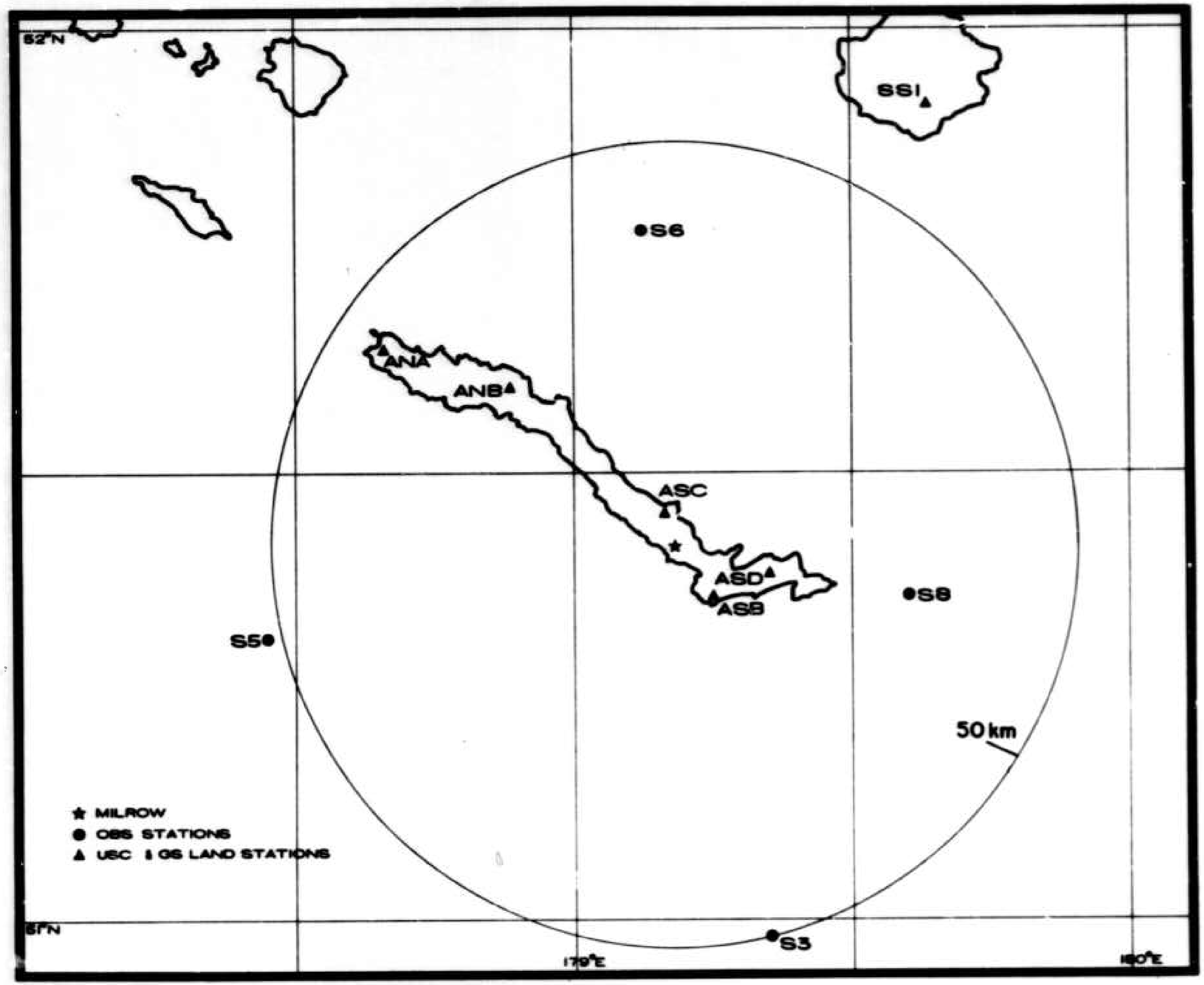


Figure II-15. Combined Station Network for Hypocenter Calculations

Table II-11

SYNOPSIS OF ALL EVENTS PROCESSED IN THE VICINITY OF MILROW

Date	Origin Time	Latitude	Longitude	Depth (km) X Indicates Negative Depth	Station Residuals (— indicates an observation) ASB		ASC		ASD		ANA		ANB		SS1		S03		S05		S06		S08		Remarks
					P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	
10-02-69	22:05:59.8	51.42	179.20	6	0.05		-0.04						-0.26		—		-0.17		0.28		-0.01		0.49		MILROW
10-04-69	10:56			X	—				—		—				—				—		—		—		MILROW collapse
10-03-69	03:41:56.4	51.42	179.21	6	-0.53		-0.66	-0.60	-0.18										-0.03	-0.04	-0.24	0.48	-0.36	0.99	MILROW residual applied
10-03-69	04:37:15.2	51.38	179.14	2	0.12		-0.45	-0.73	-0.05		0.04												-0.44	0.76	MILROW residual applied
10-03-69	04:45			X	—		—	—	—	—	—								—	—	—		—	—	
10-03-69	05:35			X	—		—	—	—	—	—								—	—			—	—	
10-03-69	05:48			X	—		—	—	—	—									—	—			—	—	
10-03-69	06:16			X	—		—		—											—			—	—	
10-03-69	06:17:58.8	51.44	179.23	7	-0.79	-1.01	-0.67	—	0.06	0.41	-0.92								-0.03	0.39	—	1.12	—	—	
10-03-69	06:37:03.5	51.42	179.20	6	-0.57	-0.51	-0.70	-0.55	-0.32	0.14	-1.04								0.05	0.79	-0.01	1.27			
10-03-69	06:39:03.0	51.41	179.22	3	-0.17		-0.75	-0.72	0.08	0.78	—								-0.20	0.35	0.16	-0.25			
10-03-69	06:50			X	—	—	—	—	—	—									—	—			—	—	
10-03-69	07:06:03.5	51.42	179.26	7	-0.45	-0.41	-1.04	-1.33	0.52	1.22									-0.21	0.17		0.08			
10-03-69	07:10:45.2	51.43	179.25	7	-0.38		-0.97	-1.17	0.42	0.92									-0.18	0.16	—	0.09			
10-03-69	07:35:52.4	51.46	179.18	6	-0.09	0.24	-0.01	0.19	-1.13	-1.66									-0.48	1.00	0.06		0.36	0.44	MILROW residual applied
10-03-69	07:40:32.2	51.42	179.20	4	-0.59	-0.28	-0.91	-0.68	-0.51	0.04									-0.24	0.52	—	0.08	-0.03	0.59	
10-03-69	08:18:52.1	51.43	179.17	4	-0.98		-0.47	0.08	-0.89	-0.94	-1.29								0.14	0.78	-0.86	2.66	-0.59	1.24	
10-03-69	08:37:40.8	51.49	179.24	3	-0.78	-1.32	0.36	0.50	0.40	0.60										-0.11	-0.10				MILROW residual applied
10-03-69	08:39			X	—	—	—	—	—	—										—	—			—	
10-03-69	10:40:16.9	51.43	179.23	5	-0.47	-0.56	-0.32	0.02	0.18	0.69									-0.06	0.01	—				
10-03-69	10:43:06.3	51.43	179.22	7	-0.86		-0.83	-0.92	-0.27	0.17	-1.10								-0.07	0.47	-0.10	1.45			
10-03-69	11:04:51.2	51.41	179.23	5	-0.39		-1.03	-0.97	0.28	0.91										-0.03	-0.19	0.40			
10-03-69	11:40:22.5	51.39	179.15	4	0.14		-0.34	-0.36	-0.07	-0.07	0.03										—		-0.27	0.50	MILROW residual applied
10-03-69	13:09			X	—		—		—	—									—	—	—				
10-03-69	13:29			X	—	—	—	—	—	—										—	—				
10-03-69	13:52:38.3	51.45	179.24	9	-0.88		-0.96		-0.14		-0.71				—		-0.18		0.01	1.06	0.32		0.74		
10-03-69	14:52:36.9	51.44	179.26	8	-0.44	-0.78	-0.71	-1.04	0.69	0.95									-0.16	0.31	0.05				
10-03-69	15:44			X	—		—	—	—								—		—	—	—				
10-03-69	19:16:46.5	51.42	179.24	5	-0.30		-0.92	-0.92	0.32	0.99										0.04	-0.17	0.37			
10-03-69	19:34:07.4	51.43	179.20	6	-0.98		-0.86	-0.68	-0.57								—		-0.14	0.30	-0.33	0.71	-0.01	0.85	
10-03-69	20:08:50.4	51.41	179.24	5	-0.36		-0.82	-0.84	0.26	1.01									-0.15	0.30	0.12	-0.07			
10-04-69	05.23			X	—		—	—	—											—	—	—		—	
10-04-69	06:34:03.7	51.44	179.20	5	-1.16		-0.68	-0.32	-0.61								0.02		-0.05	0.27	-0.38	0.76		0.77	
10-04-69	06:34			X	—		—	—	—										—	—				—	
10-04-69	06:48:53.3	51.44	179.25	4	-0.30		-0.18	0.07	0.51											0.00		0.00	0.01		MILROW residual applied
10-04-69	07:31:36.8	51.44	179.17	7	-1.30		-0.34	-0.22	-0.83										-0.67	1.13	-0.18	0.36	0.52		MILROW residual applied
10-04-69	08:41:57.0	51.38	179.05	2	-0.03		0.15	-0.38	-0.20											—			-0.02	0.01	
10-04-69	08:43:20.6	51.44	179.24	4	-0.44		-0.26	0.02	0.31										-0.37	-0.04	—			—	MILROW residual applied
10-04-69	08:45			X	—		—	—	—	—										—			—	—	
10-04 69	08:48			X	—	—	—	—	—										—	—			—		
10-04-69	08:51			X	—		—		—										—	—	—	—	—		
10-04-69	09:06:25.3	51.42	179.17	2	-0.31		0.16		-0.37		-0.50				—				0.22		-0.24	0.91	-0.02		
10-04-69	09:11			X	—	—	—	—	—	—									—	—	—		—	—	
10-04-69	17:57			X	—		—	—	—	—											—	—	—	—	

Table II-12

SYNOPSIS OF ALL EVENTS PROCESSED EXCEPT THOSE IN VICINITY OF MILROW

Date	Origin Time	Latitude	Longitude	Depth (km) X Indicates Negative Depth	Station Residuals (— Indicates an observation) ASB P	ASB S	ASC P	ASC S	ASD P	ASD S	ANA P	ANA S	ANB P	ANB S	SSI P	SSI S	S03 P	S03 S	S05 P	S05 S	S06 P	S06 S	S08 P	S08 S	Remarks
9-28-69	06:55																								Distance > 180 km
9-28-69	22:25			X			—	—	—	—					—	—			—	—	—	—			
9-29-69	07:22:46.4	51:03	178:80	27	0.21		0.08		-0.07	0.20	-0.64				-0.04				0.59	0.13	-0.14	0.92	0.49	-1.04	
9-29-69	13:43:42.1	51:10	-179.92	27					-0.49	-0.89					-0.10	-0.39				-0.17	0.09	0.50	0.57	0.82	
9-30-69	04:50				—		—												—		—	—	—	—	Near convergence
9-30-69	06:10				—	—	—		—	—	—	—			—	—			—	—	—	—	—	—	Distance > 180 km
9-30-69	08:06			X	—		—		—							—			—	—	—	—			
9-30-69	10:54:53.3	51.39	179.64	63	0.09	0.02	—	—	0.02	-0.20	-0.42				-0.42				—	—	0.71	0.04			
9-30-69	14:53				—				—	—	—				—	—	—		—	—	—	—	—		Distance > 180 km
10-01-69	01:41				—		—		—	—	—				—	—	—		—	—	—	—	—		Near convergence
10-01-69	03:29:53.7	5!.11	-179.99	27	-0.45		-0.34		-0.12						-0.24	-0.08			0.29	-0.44	0.13	0.50	0.42	0.92	
10-01-69	07:53:53.1	51.12	179.13	33															-0.17	0.26	-0.35	0.54	0.68	1.30	
10-02-69	03:21																		—	—	—	—	—	—	Distance > 180 km
10-02-69	06:18																		—	—	—	—	—	—	Distance > 180 km
10-03-69	06:41:16.9	51.21	-179.96	27	0.31	0.42	-0.68		0.22	0.16	0.24	0.28			-0.26				-0.06	-0.63	0.01				
10-03-69	07:28:09.6	52.00	179.82	157	-0.19		-0.02	-0.01	-0.25	-0.54	-0.08	-0.96			-0.24	1.19	—		0.42	0.25	-0.16		-0.01	0.27	
10-03-69	13:49:02.0	51.46	179.99	36	-0.66	0.37	-0.69	0.08	-0.67	0.62	-1.05	-0.20			0.79	1.08	-0.97	1.28	0.81	0.28	-0.61				
10-03-69	15:46:40.7	51.94	178.08	116	-0.28		0.02	0.38	-0.37		0.07				-0.28		-0.33	—	0.25	-0.41	-0.14		0.70		
10-04-69	07:33:14.8	51.42	179.31	50															-0.31	0.27	0.13	-0.48	0.07	-0.34	
10-04-69	08:03:25.3	51.18	178.76	30	0.04		0.21		-0.23		-0.22				-0.05		-0.06		0.23		0.26		0.28		
10-04-69	22:14:31.9	51.25	178.94	40	-0.52		-0.22	-0.26	-0.38		-0.13	-1.20			-0.30	0.25			0.61		0.22	0.66	0.04	0.67	
10-05-69	10:22:43.5	51.20	178.87	24	0.03	0.02	0.04	-0.03	-0.06	-0.48										-0.19	-0.09	-0.02			
10-05-69	16:31:16.4	51.17	179.35	24	0.38	-2.11	0.08		0.22	-2.76					-0.36				-0.28	0.11		0.61	0.55	0.62	
10-05-69	20:59:17.5	51:36	178.85	45	-0.50	-0.35	-0.24	-0.21	-0.39		-0.33	-1.45			-0.11	-0.13	-0.02		0.18	0.90	0.18	0.81	-0.10	0.65	
10-05-69	21:11:10.2	51.81	178.45	136	0.11	0.62			-0.27	-0.21										-0.09	0.23	-0.31			
10-05-69	21:17:47.2	51.17	178.80	20	0.33	-0.36	0.38	-0.02	0.10	-1.17	-0.62								0.10	0.59	-0.08	0.60			
10-06-69	08:43:51.1	51.60	179.03	118.	-0.35	0.45	-0.10	1.12	-0.80	0.04												-0.19	0.81	-0.98	
10-06-69	12:29				—	—	—		—	—					—	—			—	—	—	—			Distance > 180 km
10-06-69	12:37			X	—		—		—	—					—	—			—	—	—	—	—	—	
10-06-69	15:05				—	—	—		—		—				—	—	—	—		—		—	—	—	
10-06-69	16:20				—		—		—		—				—	—	—	—		—		—	—	—	Distance > 180 km
10-06-69	18:05:04.9	51.55	179.11	63	-0.28	-0.53	—	-0.02	-0.33	-1.82	-0.47	-0.86			-0.53	0.29			0.16	0.51	0.18	1.30	0.23	1.16	
10-06-69	18:49:37.5	52.00	178.21	141	-0.19		-0.28	0.25	-0.19	-0.97	0.00	-0.96			-0.24		-0.14		0.44	0.06	0.21	0.72	0.38	0.82	
10-06-69	20:09			X	—	—			—	—	—	—							—	—	—	—			
10-06-69	21:40:49.7	51.21	179.43	22	-0.35		-0.50		-0.22	0.06					-0.32	0.0[illegible]	0.87		0.67	-1.12	-0.35	0.57	0.39	1.[illegible]	
10-07-69	02:10:08.5	51.30	178.82	31	-0.37		-0.06	0.93	-0.53		-0.53				-0.76	-0.77	-1.17		-0.20		0.66	2.09	2.15	0.40	
10-07-69	02:36:39.0	51.27	178.81	39	0.03		-0.01		-0.04	0.03	-0.34	-0.53			-0.03		-0.30		0.26	0.12					
10-07-69	05:36				—	—			—						—	—			—	—			—	—	Near convergence
10-07-69	08:48				—	—			—	—	—	—								—			—	—	Distance > 180 km
10-07-69	12:02:36.8	51.18	178.86	22	-0.61	0.80													0.79	-1.75	-0.2[illegible]	0.37			
10-07-69	13:31:20.9	51.13	179.92	28	-0.20		-0.19		-0.09		-0.73				-0.13	0.38			0.38	0.25	0.49	—	—	—	
10-07-69	16:28			X	—	—	—		—	—					—	—	—		—	—	—	—	—	—	
10-07-69	22:10				—		—		—	—					—	—		—			—	—	—	—	
10-07-69	22:12:42.3	51.20	179.96	25	-0.34		-0.13		-0.17		0.11				-0.39		0.11		-0.04		0.61		1.25		
10-07-69	22:22				—	—	—		—						—					—	—	—	—	—	Distance > 180 km
10-07-69	23:53				—				—						—		—	—	—	—	—	—	—	—	
10-08-69	09:01				—	—	—		—	—	—				—		—	—	—		—	—	—		Near convergence

Table II-12 (Contd)

Date	Origin Time	Latitude	Longitude	Depth (km) X Indicates Negative Depth	Station Residuals (— indicates an observation) ASB P	ASB S	ASC P	ASC S	ASD P	ASD S	ANA P	ANA S	ANB P	ANB S	SSI P	SSI S	S03 P	S03 S	S05 P	S05 S	S06 P	S06 S	S08 P	S08 S	Remarks
10-08-69	09:03			X	—				—	—	—				—	—				—	—	—	—	—	Near convergence
10-08-69	10:08:05.4	50.94	178.48	40	-1.26	-1.66			-1.25	-1.48					0.05		0.70	2.14	-0.45	0.52	-0.07	1.84	-0.18	0.56	
10-08-69	11:42:45.2	51.44	178.72	29	0.52		0.31		-0.86		-0.37				-0.23		0.19		0.11		0.46		0.55		
10-08-69	13:57																		—	—	—	—	—	—	
10-08-69	18:27			X	—	—	—		—		—	—						—	—	—	—	—			
10-08-69	20:51:43.4	51.70	179.82	88	-0.36	-1.08	-0.35	-0.29	-0.50	-0.60	-0.31	-0.27						0.98	0.11	0.41	0.42	1.33	0.34	0.33	
10-09-69	02:09:28.7	51.48	178.79	61	-0.46				-0.36	-0.27	-1.05	-0.62			-0.54	-0.26	0.19	-1.21	0.32	-0.57	0.28	1.66	0.53	0.92	
10-09-69	03:54:26.6	51.72	178.89	71	-0.99	-1.18			-0.99	-1.45	-0.19	-0.21						1.37	0.06	0.18	0.44	1.56	0.23	0.72	
10-09-69	04:42			X	—				—	—					—	—				—	—	—	—	—	
10-09-69	12:11				—		—		—						—						—	—	—		Near convergence
10-09-69	13:16:44.6	51.54	-179.58	70	-0.18	-0.14	-0.41		-0.45	-0.58	0.11	-0.02			-0.07	-0.32							0.36	0.61	
10-09-69	21:54			X											—	—	—	—			—	—	—	—	
10-09-69	23:11:00.9	51.62	-179.15	72											0.09	-0.72	0.06	0.32		-0.43	-0.33	1.36	0.02	-0.83	
10-10-69	06:33			X	—				—	—															
10-10-69	08:19:36.2	50.96	179.21	20	-0.84	-1.55			-1.15								1.30	3.74	-0.38	-0.01	0.17	1.09	-0.46	-0.29	
10-10-69	08:22:18.5	51.57	179.54	73	-0.71	-1.09	-0.41		-0.79	-0.92					0.17		-0.76	1.71	0.33	-0.19	-0.03	0.26	0.32	1.07	
10-10-69	08:54:16.4	50.96	179.59	27	-0.78	-3.22			-0.54	-2.82							1.53	1.15	-0.58	0.95	-0.80	2.31	1.00	0.03	
10-10-69	11:01																		—	—	—	—	—	—	
10-10-69	18:20:45.7	51.11	179.22	34	-0.65	-1.56			-0.74						-0.05	-0.16	0.44	2.00	-0.30	0.08	0.20	1.41			
10-10-69	21:31:05.6	51.74	-179.37	95	-0.71	-1.24			-0.69								0.11	1.18	0.07	-0.24	0.48	0.54	0.07	0.02	
10-11-69	02:03			X					—	—							—	—			—	—			
10-11-69	04:51:03.5	51.72	178.47	82	-0.37	-0.27			-0.30	-0.42					-0.35	-1.34	-0.30	-0.85	-0.15	0.32	0.12	1.00	0.80	1.57	
10-11-69	16:29:12.2	50.86	179.27	35													0.88	1.00		-0.64	-0.18	1.10	0.01	-1.85	
10-11-69	20:42:23.1	51.00	179.57	27	-0.15	0.19			-0.37	0.12					-0.14	0.98	-0.02		0.02	0.59	0.10	-1.16	0.04	—	
10-11-69	22:53			X	—				—	—					—			—	—	—	—	—	—	—	
10-11-69	23:02:46.5	52.00	177.76	109					-1.46	-0.94								0.04	-0.25	1.02	-0.48	1.12	1.18	-0.03	
10-11-69	23:29:00.0	51.20	178.55	12	-0.56	-1.83			-0.95	-1.81					-0.69	1.37	0.88		1.18		-0.13	0.73	0.24	0.49	
10-12-69	06:56				—	—			—	—					—				—	—	—	—	—	—	Near convergence
10-12-69	12:40				—	—			—	—					—	—	—	—	—	—	—	—	—	—	Distance > 180 km
10-12-69	20:40			X											—	—			—	—	—	—	—		
10-12-69	20:58:26.3	51.22	-179.95	120													-0.23	0.42	0.17	-0.26	0.01	—	0.04	—	
10-13-69	06:16:19.2	51.59	179.16	21	0.05	-0.37			0.03	-0.33											-1.21	1.49			
10-13-69	06:51:18.7	51.15	178.13	34	-1.55	1.37			-1.59	0.15									-0.67	2.64	1.17	-1.87	-0.12	2.34	
10-13-69	06:55				—	—			—	—									—	—		—	—	—	Near convergence
10-13-69	12:01:46.0	52.01	178.01	76	-1.20	-0.04			-1.05	-0.13								-0.23	-0.24	1.48			1.22	0.27	
10-13-69	19:35:02.9	51.04	-179.94	24	0.12				-0.13						-0.05	0.01			-0.01	-0.11					
10-14-69	06:55				—				—						—	—	—		—		—	—	—		Near convergence
10-14-69	17:02:29.5	51.07	-179.84	29	-0.40				-0.22						-0.08	-0.21						0.48	1.04	-0.66	
10-15-69	06:19:14.6	51.39	178.92	57	-0.37	-0.95	-0.15	-0.36	-0.46	-0.62					-0.35	-0.33			-0.22	0.24	0.21	0.51	0.39	0.84	
10-15-69	09:56				—	—			—	—					—	—	—			—	—	—			Distance > 180 km
10-15-69	13:13			X	—	—	—		—	—					—	—			—	—	—	—			
10-15-69	13:26			X	—	—			—	—					—	—						—			
10-15-69	15:43:35.8	51.36	178.82	39	-0.06				-0.04	-0.19										-0.07	-0.09	0.02			
10-16-69	01:14:32.0	51.55	178.27	79	-0.48	0.84	-0.22	1.06	-0.20	0.35					-0.30	-1.07			-0.52	-0.84	1.25	-0.32			
10-16-69	04:13:35.4	51.30	178.14	42	-1.01	0.71	0.61		-0.85						-0.09				0.13		-0.02		0.49		
10-16-69	12:59				—	—	—		—	—					—	—			—	—					Distance > 180 km
10-16-69	15:30			X	—				—						—	—		—	—	—					
10-16-69	15:59				—				—						—	—			—	—	—	—			Distance > 180 km
10-17-69	00:30:17.1	51.62	-179.62	55	-0.89	-0.10			-0.87	0.23					-0.12	1.18		0.97	0.40	-0.49					

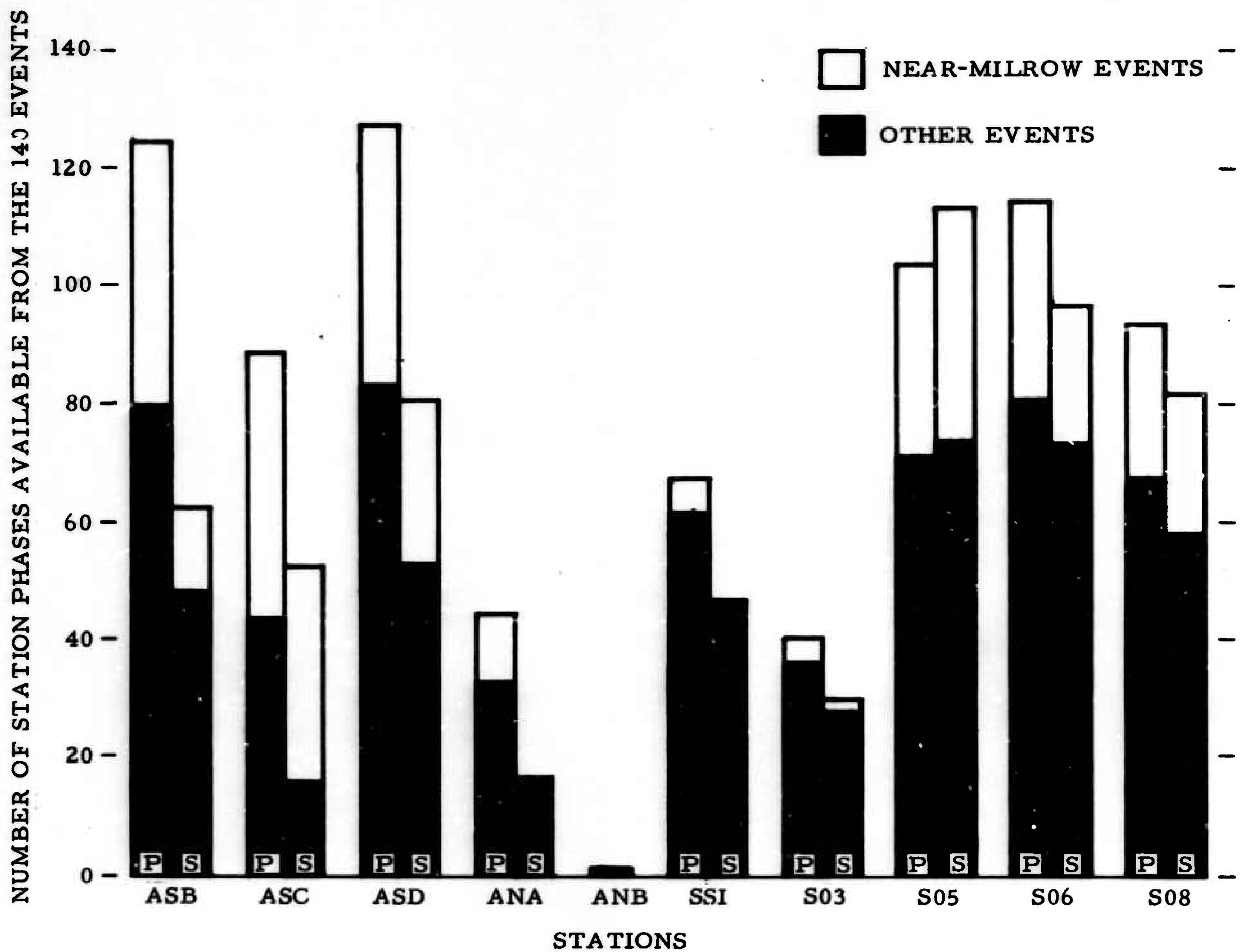


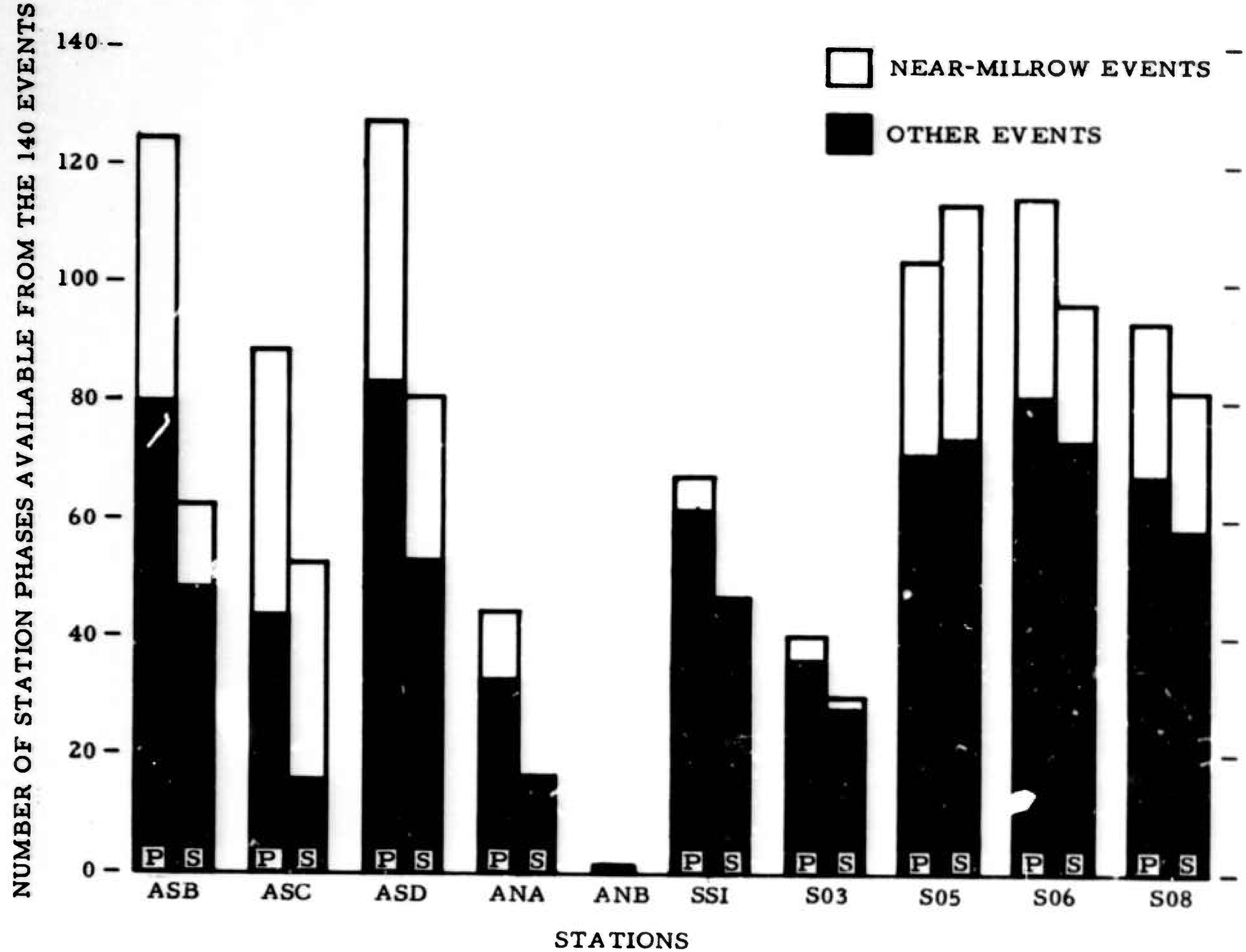
Figure II-16. Histogram of Available Raw Data

Previous investigators[4,6,7,8] have discussed the problems involved in hypocenter calculation. Each of these problems requires considerably more investigation which could not possibly have been attempted in this work. It should be pointed out, however, that errors due to gross inaccuracies in the model in general are small (a Jeffreys-Bullen or California crust is normally assumed) in comparison to the error component which is sensitive to the azimuthal distribution of the subset of observing stations and the spacing of that subset. Furthermore, much more station data are required for a solution when the epicenter lies outside the network. With the exception of an event at 2009Z on 6 October, refined hypocenters were found for all events lying inside the network (see Figure II-17) and residing outside the immediate vicinity of MILROW. The generality of the hypocenter-calculation process is further evidenced by the fact that solutions appear in all azimuthal quadrants and out to the maximum range of the process.

An inspection of Figure II-17 shows that, in general, events to the south of the island arc are shallow focus whereas events to the north of the island arc are deep focus. This observation is in agreement with other seismicity studies in the Aleutian Islands region.[5] The principal departure from normal seismicity in the area occurs around the MILROW location where numerous very-shallow-focus (2 to 10 km) events are located within a radius of about 7 km and occur within about 37 hr after the MILROW event.

Table II-13 lists the events charted in Figure II-17. The list includes date, origin time, latitude, longitude, depth of focus, number of phases used in the solution, standard deviation of the solution, station code, phase type in conventional USC&GS form, corrected arrival time, raw arrival time, and time residual for each arrival.

The corrected arrival time is the observed GCT (raw) arrival time reduced to sea level. OBS stations below sea level have positive corrections, while land stations above sea level have negative corrections. Table II-10 lists the corrections used for P and S arrivals at each station.



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Correlation of the data of Tables II-11 and II-12 with Table II-13 and Figure II-17 shows two principal geographic areas of concern — MILROW vicinity and an area to the southeast at about 70 to 90 km from MILROW. Only 19 of the 44 near-MILROW events converged to solution; similarly, about one-half of the events in the southeast area converged. The remainder of the solutions indicates that the process worked well on nearly all of the other associated events tested.

In an attempt to increase the number of solutions for the 44 associated near-MILROW events, the events were reprocessed using MILROW residuals where available to correct raw traveltimes. The reprocessing resulted in eight additional solutions for near-MILROW events and also a solution for MILROW. One solution obtained earlier without correction for MILROW residuals failed when the residuals were applied. Therefore, the net gain in solutions was 7. The 26 solutions for the near-MILROW events are shown in Table II-14.

There are several factors related to assessing the increase in number of solutions. The data characteristics are summarized as follows:

- The residual-corrected MILROW solution and the uncorrected solution give identical epicenters but slightly different depths
- The epicenter scatter seems larger for the residual-corrected set (see inset in Figure II-17)
- The scatter for both sets is much broader (generally 7 to 8 km) than the location error (<2 km) for the calculated epicenter of MILROW proper
- Examination of graphical solutions (applying the velocity model used in hypocenter calculations) for the tripartite ASB, ASC, and ASD showed solution triangles which cluster south and west of the MILROW site, whereas the combined net moves the cluster of near-MILROW epicenters to the northeast of the MILROW site

Several factors might combine to explain the behavior noted. There is a position uncertainty (~ 1 km) associated with the OBS network which might bias the data to the northeast. Even though more solutions were obtained with the residual-corrected data, the wider scatter might be explained by the lack of residuals for the ASD, ANA, and SSI data which were used in the residual-corrected calculations. It is also noted from Tables II-11 and II-12 that the preponderance of the residuals at ASB and ASC (for the uncorrected calculation on the entire data set) are negative and many times larger than actual MILROW residuals. It may be that, when the networks are combined, the MILROW tripartite behaves almost as one station. SSI, as seen in Table II-13, did not enter into the solutions for near-MILROW events and does not furnish any insight into the near-MILROW problem. However, SSI was available consistently for hypocenter calculations for all other events. One final point for speculation is the effect of a finite geometry for the source mechanisms near MILROW; i.e., departure from a point-source behavior for these mechanism could introduce significant errors at the near tripartite of ASB, ASC, and ASD. Further, it seems plausible that each event did not come from the same source and the sources might be distributed along a fault system near MILROW.

In summary, it is doubtful that these effects can be collectively rationalized in the context of the experiment reported here. Certainly, more work could be done in the future to seismically calibrate the MILROW vicinity in an attempt to remove any velocity-model and/or observation-network deficiencies.

As far as the problem in the southeast is concerned, no significant trend could be established from the data available. Since the events lie outside the network, a concentrated effort for solution was not attempted. It is possible that constraining depth and origin time or manipulation of the subarrays might produce additional solutions in this area, but time did not permit such an investigation.

2.4.3 HYPOCENTER ACCURACY IN MILROW VICINITY. In order to examine the epicentral location capability of the combined network for events occurring at the MILROW site, theoretical arrival times were calculated for P and S waves as observed at the two closest land stations and the four OBS stations for the following hypocenter:

Origin time	= 22:01:30.0
Latitude	= 51.417°N
Longitude	= 179.182°E
Depth	= 1.2 km

The station elevations were taken as sea level, thereby eliminating the station correction factors. The theoretical arrival times were rounded to the nearest tenth of a second to simulate the experimental accuracy in reading arrival times from the seismograms. Next, the theoretical arrival times were input to the hypocenter-calculation program, yielding the following results.

```
OCT    2, 1969
H = 22   1 30.0
LATITUDE =     51.417 N
LONGITUDE =    179.181 E
DEPTH =    3.8 KM
NUMBER OF PHASES USED = 12          STANDARD DEVIATION =    0.06 SEC
```

		CORR. TIME	RAW TIME	
ASC	P	22 1 31.4	22 1 31.4	RES = -0.08 SEC
ASC	S	22 1 32.4	22 1 32.4	RES = -0.15 SEC
SC3	P	22 1 39.9	22 1 39.9	RES = -0.02 SEC
SC3	S	22 1 47.2	22 1 47.2	RES = 0.04 SEC
SC5	P	22 1 40.3	22 1 40.3	RES = 0.02 SEC
SC5	S	22 1 47.8	22 1 47.8	RES = 0.02 SEC
SC6	P	22 1 38.4	22 1 38.4	RES = -0.01 SEC
SC6	S	22 1 44.6	22 1 44.6	RES = 0.03 SEC
SC8	P	22 1 36.0	22 1 36.0	RES = 0.04 SEC
SC8	S	22 1 40.4	22 1 40.4	RES = 0.04 SEC
ASB	P	22 1 31.9	22 1 31.9	RES = -0.02 SEC
ASB	S	22 1 33.2	22 1 33.2	RES = -0.10 SEC

The resulting epicenter location is in very close agreement; this was expected, since the stations were fairly evenly distributed in azimuth about the epicenter. The calculated focal depth was 3.8 km. It is well-known that accurate depth determination requires the observation of arrivals which have propagated along differing refractors and, more importantly, requires the observation of at least one direct arrival. In this example, the first arrival to all stations propagates in one refractor only — shallow Pg. If the S-wave arrivals had been excluded from this example, there would be no control on the depth because a change in depth would be compensated by a shift in origin time. The inclusion of P and S waves provides constraint on the calculated origin time and resultant depth.

Another set of theoretical arrival times was calculated for a focal depth of 10 km and input to the hypocenter-calculation program, yielding the following results.

```
OCT    2, 1969
H = 22  1 30.0
LATITUDE =    51.419 N
LONGITUDE =  179.187 E
DEPTH = 10.9 KM
NUMBER OF PHASES USED = 12            STANDARD DEVIATION =    0.16 SEC

                   CORR. TIME        RAW TIME

ASC     P         22   1 32.7      22   1 32.7          RES =    0.15 SEC
ASC     S         22   1 34.7      22   1 34.7          RES =    0.34 SEC
SC3     P         22   1 39.8      22   1 39.8          RES =    0.02 SEC
SC3     S         22   1 46.9      22   1 46.9          RES =    0.07 SEC
SC5     P         22   1 40.0      22   1 40.0          RES =   -0.05 SEC
SC5     S         22   1 47.4      22   1 47.4          RES =    0.02 SEC
SC6     P         22   1 38.5      22   1 38.5          RES =    0.00 SEC
SC6     S         22   1 44.8      22   1 44.8          RES =    0.08 SEC
SC8     P         22   1 36.2      22   1 36.2          RES =   -0.04 SEC
SC8     S         22   1 40.7      22   1 40.7          RES =   -0.07 SEC
ASB     P         22   1 32.6      22   1 32.6          RES =   -0.24 SEC
ASB     S         22   1 34.5      22   1 34.5          RES =   -0.31 SEC
```

Again, the epicenter location is in very close agreement. The calculated focal depth was 10.9 km. In this example, the hypocenter was in very close agreement, since the conditions for accurate depth determination were more nearly fulfilled; i.e., the arrivals at the two closest stations, ASC and ASB, were direct arrivals and the arrivals to the OBS stations were refractions in the Pg refractor. The foregoing exercise is applicable only in the vicinity of MILROW. Due to the previously described shortcomings of the hypocenter-location process, extension of the preceding results to other geographic areas in not warranted.

2.4.4 CRITIQUE. Although the useful OBS data were limited at best to four stations, it is apparent that improved hypocenters for events occurring within the net were obtained — as opposed to hypocenters based only on data from the land-station net — because of the following:

- Additional P-wave observations
- Additional S-wave observations, yielding more control on origin-time estimates and resultant calculated depths
- Better azimuthal coverage
- Addition of direct-arrival observations in many cases for accurate depth calculations

Hypocenter-location accuracy is, of course, a function of many variables, one being the model estimate which must accurately represent the velocity/depth relationship in the area if the resultant hypocenter calculations are to be meaningful. The model used is almost certainly an oversimplification of the true crust. The model was based on traveltime information from controlled explosions and assumed constant-velocity plane layering. The adequacy of that assumption was demonstrated in subsection 2.3 for the available traveltime data. The inclusion of traveltimes from additional controlled explosions in the area geometrically distributed in such a manner as to provide denser sampling of the refractors would probably show perturbations in the model. The hypocenter-location problem then would involve traveltime calculations for a 3-dimensional model, with layers that change dip in two directions.

As demonstrated earlier, accurate focal depth cannot be obtained for those events occurring at the MILROW hypocenter, since the land-net data did not include a station sufficiently close to record the direct P and S waves as first arrivals. A seismogram analysis of secondary arrivals at those stations would probably allow identification and timing of the direct P and S waves which could be used for accurate depth calculations.

In order to determine the probable causes of failure of solutions for 37 events, additional study which is beyond the time frame of the present analysis is indicated. Areas of investigation which could prove fruitful are as follows:

- Perform hypocenter calculations using different subsets of stations
- Perform hypocenter calculations using different weightings on the P and S arrival-time picks
- Perform hypocenter calculations using mean station-time residuals
- For events out of range, attempt to find station subsets with Δ's less than 180 km and repeat the hypocenter calculations using that station subset
- Perform hypocenter calculations with the origin time constrained (based on the P-to-S interval) or with the depth constrained
- Perform hypocenter calculations for convergence parameters of varying size (in km)
- Perform a visual signal-to-noise analysis of the P and S waves for each event

Table II-13

FINAL HYPOCENTER LOCATIONS

SEPT 29, 1969
H = 7 22 46.4
LATITUDE = 51.034 N
LONGITUDE = 178.797 E
DEPTH = 27 KM
NUMBER OF PHASES USED = 12 STANDARD DEVIATION = 0.50 SEC

		CORR. TIME	RAW TIME		
SC8	-IP	7 22 58.9	7 22 58.6	RES =	0.49 SEC
SC8	ES	7 23 6.2	7 23 5.6	RES =	-1.04 SEC
SC5	+IP	7 22 55.2	7 22 54.9	RES =	0.59 SEC
SC5	ES	7 23 0.7	7 23 0.2	RES =	0.13 SEC
SC6	EP	7 23 1.2	7 23 1.0	RES =	-0.14 SEC
SC6	ES	7 23 13.1	7 23 12.8	RES =	0.92 SEC
ASD	IPG	7 22 56.7	7 22 56.7	RES =	-0.07 SEC
ASD	IS	7 23 4.5	7 23 4.5	RES =	0.20 SEC
ASB	IPG	7 22 56.0	7 22 56.0	RES =	0.21 SEC
SSI	IPG	7 23 5.2	7 23 5.3	RES =	0.04 SEC
ASC	IPG	7 22 56.7	7 22 56.7	RES =	0.08 SEC
ANA	IPG	7 22 57.8	7 22 57.8	RES =	-0.64 SEC

SEPT 29, 1969
H = 13 43 42.1
LATITUDE = 51.103 N
LONGITUDE = 179.916 W
DEPTH = 27 KM
NUMBER OF PHASES USED = 9 STANDARD DEVIATION = 0.52 SEC

		CORR. TIME	RAW TIME		
SC8	EP	13 43 51.6	13 43 51.3	RES =	0.57 SEC
SC8	ES	13 43 58.5	13 43 57.9	RES =	0.82 SEC
SC6	EP	13 43 59.3	13 43 59.1	RES =	0.09 SEC
SC6	ES	13 44 12.2	13 44 11.9	RES =	0.50 SEC
SO5	ES	13 44 15.0	13 44 14.5	RES =	-0.17 SEC
ASD	IPG	13 43 52.8	13 43 52.8	RES =	-0.49 SEC
ASD	IS	13 44 0.6	13 44 0.6	RES =	-0.89 SEC
SSI	EPG	13 43 58.1	13 43 58.2	RES =	-0.10 SEC
SSI	ES	13 44 9.7	13 44 9.8	RES =	-0.39 SEC

Table II-13 (Contd)

SEPT 30, 1969
H = 10 54 53.3
LATITUDE = 51.387 N
LONGITUDE = 179.635 E
DEPTH = 63 KM
NUMBER OF PHASES USED = 8 STANDARD DEVIATION = 0.34 SEC

		CORR. TIME	RAW TIME		
SC6	E(P)	10 55 6.8	10 55 6.6	RES =	0.71 SEC
SC6	ES	10 55 15.4	10 55 15.1	RES =	0.04 SEC
ASD	IPG	10 55 3.4	10 55 3.4	RES =	0.02 SEC
ASD	IS	10 55 10.5	10 55 10.5	RES =	-0.20 SEC
ASB	EPG	10 55 3.8	10 55 3.8	RES =	0.09 SEC
ASB	IS	10 55 11.3	10 55 11.3	RES =	0.02 SEC
ANA	IPG	10 55 7.2	10 55 7.2	RES =	-0.42 SEC
SSI	EPG	10 55 5.7	10 55 5.8	RES =	-0.42 SEC

OCT 1, 1969
H = 3 29 53.7
LATITUDE = 51.108 N
LONGITUDE = 179.997 W
DEPTH = 27 KM
NUMBER OF PHASES USED = 11 STANDARD DEVIATION = 0.43 SEC

		CORR. TIME	RAW TIME		
SC8	+IP	3 30 2.5	3 30 2.2	RES =	0.42 SEC
SC8	ES	3 30 9.2	3 30 8.6	RES =	0.94 SEC
SC6	EP	3 30 10.4	3 30 10.2	RES =	0.13 SEC
SC6	ES	3 30 22.8	3 30 22.5	RES =	0.50 SEC
SC5	EP	3 30 12.3	3 30 12.0	RES =	0.29 SEC
SC5	ES	3 30 24.9	3 30 24.4	RES =	-0.44 SEC
ASD	EPG	3 30 4.1	3 30 4.1	RES =	-0.12 SEC
ASB	EPG	3 30 4.3	3 30 4.3	RES =	-0.46 SEC
ASC	EPG	3 30 6.0	3 30 6.0	RES =	-0.34 SEC
SSI	EPG	3 30 9.3	3 30 9.4	RES =	-0.24 SEC
SSI	ES	3 30 21.1	3 30 21.2	RES =	-0.08 SEC

Table II-13 (Contd)

OCT 1, 1969
H = 7 53 53.1
LATITUDE = 51.124 N
LONGITUDE = 179.130 E
DEPTH = 33 KM
NUMBER OF PHASES USED = 6 STANDARD DEVIATION = 0.66 SEC

		CORR. TIME	RAW TIME	
SC8	EP	7 54 2.8	7 54 2.5	RES = 0.68 SEC
SC8	ES	7 54 7.5	7 54 6.9	RES = -1.30 SEC
SC5	+IP	7 54 3.2	7 54 2.9	RES = -0.17 SEC
SC5	ES	7 54 11.1	7 54 10.6	RES = 0.26 SEC
SC6	-EP	7 54 6.1	7 54 5.9	RES = -0.35 SEC
SC6	ES	7 54 16.7	7 54 16.4	RES = 0.54 SEC

OCT 2, 1969
H = 22 5 59.8
LATITUDE = 51.419 N
LONGITUDE = 179.201 E
DEPTH = 6 KM
NUMBER OF PHASES USED = 7 STANDARD DEVIATION = 0.24 SEC

		CORR. TIME	RAW TIME	
ASC	IPG	22 6 1.7	22 6 1.7	RES = -0.04 SEC
ASB	IPG	22 6 2.0	22 6 2.0	RES = 0.05 SEC
ANB	IPG	22 6 6.5	22 6 6.6	RES = -0.26 SEC
SC8	+IP	22 6 6.1	22 6 5.8	RES = 0.49 SEC
SC6	IP	22 6 8.2	22 6 8.0	RES = -0.01 SEC
SC3	EP	22 6 9.5	22 6 9.1	RES = -0.17 SEC
SC5	+IP	22 6 10.6	22 6 10.3	RES = 0.28 SEC

Table II-13 (Contd)

OCT 3, 1969
H = 6 17 58.8
LATITUDE = 51.438 N
LONGITUDE = 179.231 E
DEPTH = 7 KM
NUMBER OF PHASES USED = 9 STANDARD DEVIATION = 0.71 SEC

		CORR. TIME	RAW TIME	
SC6	ES	6 18 14.0	6 18 13.7	RES = 1.12 SEC
SC5	EP	6 18 9.8	6 18 9.5	RES = -0.03 SEC
SC5	ES	6 18 18.2	6 18 17.7	RES = 0.39 SEC
ASC	IPG	6 18 0.3	6 18 0.3	RES = -0.67 SEC
ANA	EPG	6 18 7.1	6 18 7.1	RES = -0.92 SEC
ASD	IPG	6 18 1.5	6 18 1.5	RES = 0.06 SEC
ASD	IS	6 18 3.7	6 18 3.7	RES = 0.41 SEC
ASB	IPG	6 18 0.6	6 18 0.6	RES = -0.79 SEC
ASB	IS	6 18 2.2	6 18 2.2	RES = -1.01 SEC

OCT 3, 1969
H = 6 37 3.5
LATITUDE = 51.417 N
LONGITUDE = 179.199 E
DEPTH = 6 KM
NUMBER OF PHASES USED = 11 STANDARD DEVIATION = 0.66 SEC

		CORR. TIME	RAW TIME	
SC6	EP	6 37 12.0	6 37 11.8	RES = -0.01 SEC
SC6	ES	6 37 19.4	6 37 19.1	RES = 1.27 SEC
SC5	EP	6 37 14.1	6 37 13.8	RES = 0.05 SEC
SC5	ES	6 37 22.5	6 37 22.0	RES = 0.79 SEC
ASC	IPG	6 37 4.6	6 37 4.6	RES = -0.70 SEC
ASC	IS	6 37 6.0	6 37 6.[illegible]	RES = -0.55 SEC
ANA	EPG	6 37 11.4	6 37 11.[illegible]	RES = -1.04 SEC
ASD	IPG	6 37 5.8	6 37 5.8	RES = -0.32 SEC
ASD	IS	6 37 8.1	6 37 8.1	RES = 0.14 SEC
ASB	IPG	6 37 5.0	6 37 5.0	RES = -0.57 SEC
ASB	IS	6 37 6.5	6 37 6.5	RES = -0.51 SEC

Table II-13 (Contd)

OCT 3, 1969
H = 6 39 3.0
LATITUDE = 51.407 N
LONGITUDE = 179.222 E
DEPTH = 3 KM
NUMBER OF PHASES USED = 9 STANDARD DEVIATION = 0.47 SEC

		CORR. TIME	RAW TIME	
SC6	EP	6 39 11.8	6 39 11.6	RES = 0.16 SEC
SC6	ES	6 39 17.7	6 39 17.4	RES = -0.25 SEC
SC5	EP	6 39 13.5	6 39 13.2	RES = -0.20 SEC
SC5	ES	6 39 21.9	6 39 21.4	RES = 0.35 SEC
ASC	IPG	6 39 4.1	6 39 4.1	RES = -0.75 SEC
ASC	IS	6 39 5.5	6 39 5.5	RES = -0.72 SEC
ASD	IPG	6 39 5.1	6 39 5.1	RES = 0.08 SEC
ASD	IS	6 39 7.3	6 39 7.3	RES = 0.78 SEC
ASB	IPG	6 39 4.3	6 39 4.3	RES = -0.17 SEC

OCT 3, 1969
H = 6 41 16.9
LATITUDE = 51.212 N
LONGITUDE = 179.936 W
DEPTH = 27 KM
NUMBER OF PHASES USED = 11 STANDARD DEVIATION = 0.36 SEC

		CORR. TIME	RAW TIME	
SC6	EP	6 41 32.5	6 41 32.3	RES = 0.01 SEC
SC5	EP	6 41 35.3	6 41 35.0	RES = -0.06 SEC
SC5	ES	6 41 48.2	6 41 47.7	RES = -0.63 SEC
ANA	IPG	6 41 35.0	6 41 35.0	RES = 0.24 SEC
ANA	S	6 41 48.0	6 41 48.1	RES = 0.28 SEC
ASB	IPG	6 41 28.0	6 41 28.0	RES = 0.31 SEC
ASB	IS	6 41 36.0	6 41 36.0	RES = 0.42 SEC
ASD	IPG	6 41 27.2	6 41 27.2	RES = 0.22 SEC
ASD	ES	6 41 34.5	6 41 34.5	RES = 0.16 SEC
ASC	EPG	6 41 28.4	6 41 28.4	RES = -0.68 SEC
SSI	EPG	6 41 31.0	6 41 31.1	RES = -0.26 SEC

Table II-13 (Contd)

OCT 3, 1969
H = 7 6 3.5
LATITUDE = 51.424 N
LONGITUDE = 179.259 E
DEPTH = 7 KM
NUMBER OF PHASES USED = 9 STANDARD DEVIATION = 0.75 SEC

		CORR. TIME	RAW TIME	
SC6	ES	7 6 18.3	7 6 18.0	RES = 0.08 SEC
SC5	EP	7 6 14.4	7 6 14.1	RES = -0.21 SEC
SC5	ES	7 6 22.9	7 6 22.4	RES = 0.17 SEC
ASC	IPG	7 6 4.9	7 6 4.9	RES = -1.04 SEC
ASC	IS	7 6 6.4	7 6 6.4	RES = -1.33 SEC
ASD	IPG	7 6 6.2	7 6 6.2	RES = 0.52 SEC
ASD	IS	7 6 8.5	7 6 8.5	RES = 1.22 SEC
ASB	IPG	7 6 5.3	7 6 5.3	RES = -0.45 SEC
ASB	IS	7 6 7.0	7 6 7.0	RES = -0.41 SEC

OCT 3, 1969
H = 7 10 45.2
LATITUDE = 51.429 N
LONGITUDE = 179.251 E
DEPTH = 7 KM
NUMBER OF PHASES USED = 8 STANDARD DEVIATION = 0.67 SEC

		CORR. TIME	RAW TIME	
SC6	ES	7 10 59.8	7 10 59.5	RES = 0.09 SEC
SC5	EP	7 10 56.1	7 10 55.8	RES = -0.18 SEC
SC5	ES	7 11 4.5	7 11 4.0	RES = 0.16 SEC
ASC	IPG	7 10 46.6	7 10 46.6	RES = -0.97 SEC
ASC	IS	7 10 48.1	7 10 48.1	RES = -1.17 SEC
ASD	IPG	7 10 48.0	7 10 48.0	RES = 0.43 SEC
ASD	IS	7 10 50.2	7 10 50.2	RES = 0.94 SEC
ASB	IPG	7 10 47.2	7 10 47.2	RES = -0.38 SEC

Table II-13 (Contd)

OCT 3, 1969
H = 7 28 9.6
LATITUDE = 52.002 N
LONGITUDE = 179.824 E
DEPTH = 157 KM
NUMBER OF PHASES USED = 14 STANDARD DEVIATION = 0.47 SEC

		CORR. TIME	RAW TIME		
SC6	EP	7 28 31.8	7 28 31.6	RES =	-0.16 SEC
SC8	+IP	7 28 32.8	7 28 32.5	RES =	-0.01 SEC
SC5	EP	7 28 36.6	7 28 36.3	RES =	0.42 SEC
ASD	IPG	7 28 32.8	7 28 32.8	RES =	-0.25 SEC
ASB	IPG	7 28 33.2	7 28 33.2	RES =	-0.19 SEC
ASC	IPG	7 28 33.0	7 28 33.0	RES =	-0.02 SEC
ANA	IPG	7 28 33.9	7 28 33.9	RES =	-0.08 SEC
SSI	IPG	7 28 30.6	7 28 30.7	RES =	-0.24 SEC
SC8	ES	7 28 50.1	7 28 49.5	RES =	0.27 SEC
SC5	ES	7 28 55.8	7 28 55.3	RES =	0.25 SEC
ASD	IS	7 28 49.6	7 28 49.6	RES =	-0.54 SEC
ASC	IS	7 28 50.1	7 28 50.1	RES =	-0.01 SEC
ANA	IS	7 28 50.7	7 28 50.8	RES =	-0.96 SEC
SSI	IS	7 28 47.6	7 28 47.7	RES =	1.19 SEC

OCT 3, 1969
H = 7 40 32.2
LATITUDE = 51.415 N
LONGITUDE = 179.197 E
DEPTH = 4 KM
NUMBER OF PHASES USED = 11 STANDARD DEVIATION = 0.49 SEC

		CORR. TIME	RAW TIME		
SC6	E(S)	7 40 46.9	7 40 46.6	RES =	0.08 SEC
SC8	EP	7 40 37.9	7 40 37.6	RES =	-0.03 SEC
SC8	ES	7 40 42.8	7 40 42.2	RES =	0.59 SEC
SC5	EP	7 40 42.4	7 40 42.1	RES =	-0.24 SEC
SC5	ES	7 40 50.8	7 40 50.3	RES =	0.52 SEC
ASC	IPG	7 40 32.9	7 40 32.9	RES =	-0.91 SEC
ASC	IS	7 40 34.3	7 40 34.3	RES =	-0.68 SEC
ASD	IPG	7 40 34.1	7 40 34.1	RES =	-0.51 SEC
ASD	IS	7 40 36.4	7 40 36.4	RES =	0.04 SEC
ASB	IPG	7 40 33.4	7 40 33.4	RES =	-0.59 SEC
ASB	IS	7 40 35.0	7 40 35.0	RES =	-0.28 SEC

Table II-13 (Contd)

OCT 3, 1969
H = 8 18 52,1
LATITUDE = 51,430 N
LONGITUDE = 179,173 E
DEPTH = 4 KM
NUMBER OF PHASES USED = 12 STANDARD DEVIATION = 1,11 SEC

		CORR, TIME	RAW TIME		
S08	+IP	8 18 57,7	8 18 57,4	RES =	-,59 SEC
S08	ES	8 19 4,1	8 19 3,5	RES =	1,24 SEC
S06	EP	8 18 59,4	8 18 59,2	RES =	-,86 SEC
S06	ES	8 19 8,8	8 19 8,5	RES =	2,66 SEC
S05	+EP	8 19 2,5	8 19 2,2	RES =	,14 SEC
S05	ES	8 19 10,6	8 19 10,1	RES =	,78 SEC
ASC	IPG	8 18 53,0	8 18 53,0	RES =	-,48 SEC
ASC	IS	8 18 54,5	8 18 54,5	RES =	,07 SEC
ANA	IPG	8 18 59,3	8 18 59,3	RES =	-1,29 SEC
ASD	IPG	8 18 54,1	8 18 54,1	RES =	-,89 SEC
ASD	IS	8 18 56,1	8 18 56,1	RES =	-,94 SEC
ASB	IPG	8 18 53,4	8 18 53,4	RES =	-,98 SEC

OCT 3, 1969
H = 10 40 16.9
LATITUDE = 51.435 N
LONGITUDE = 179.227 E
DEPTH = 5 KM
NUMBER OF PHASES USED = 8 STANDARD DEVIATION = 0.38 SEC

		CORR. TIME	RAW TIME		
SC5	EP	10 40 27.8	10 40 27.5	RES =	-0.06 SEC
SC5	ES	10 40 35.9	10 40 35.4	RES =	0.01 SEC
ASC	IPG	10 40 18.3	10 40 18.3	RES =	-0.32 SEC
ASC	IS	10 40 19.9	10 40 19.9	RES =	0.02 SEC
ASD	IPG	10 40 19.4	10 40 19.4	RES =	0.18 SEC
ASD	IS	10 40 21.6	10 40 21.6	RES =	0.69 SEC
ASB	IPG	10 40 18.6	10 40 18.6	RES =	-0.47 SEC
ASB	IS	10 40 20.1	10 40 20.1	RES =	-0.56 SEC

Table II-13 (Contd)

OCT 3, 1969
H = 10 43 6.3
LATITUDE = 51.429 N
LONGITUDE = 179.216 E
DEPTH = 7 KM
NUMBER OF PHASES USED = 10 STANDARD DEVIATION = 0.77 SEC

		CORR. TIME	RAW TIME	
SC6	EP	10 43 14.5	10 43 14.3	RES = -0.10 SEC
SC6	ES	10 43 22.0	10 43 21.7	RES = 1.45 SEC
SC5	EP	10 43 17.1	10 43 16.8	RES = -0.07 SEC
SC5	ES	10 43 25.5	10 43 25.0	RES = 0.47 SEC
ASC	IPG	10 43 7.5	10 43 7.5	RES = -0.83 SEC
ASC	IS	10 43 8.8	10 43 8.8	RES = -0.92 SEC
ANA	FPG	10 43 14.3	10 43 14.3	RES = -1.10 SEC
ASD	IPG	10 43 8.7	10 43 8.7	RES = -0.27 SEC
ASD	IS	10 43 11.0	10 43 11.0	RES = 0.17 SEC
ASB	IPG	10 43 7.9	10 43 7.9	RES = -0.86 SEC

OCT 3, 1969
H = 11 4 51.2
LATITUDE = 51.415 N
LONGITUDE = 179.228 E
DEPTH = 5 KM
NUMBER OF PHASES USED = 8 STANDARD DEVIATION = 0.64 SEC

		CORR. TIME	RAW TIME	
SC6	EP	11 4 59.6	11 4 59.4	RES = -0.19 SEC
SC6	ES	11 5 6.4	11 5 6.1	RES = 0.40 SEC
SC5	ES	11 5 10.1	11 5 9.6	RES = -0.03 SEC
ASC	IPG	11 4 52.2	11 4 52.2	RES = -1.03 SEC
ASC	IS	11 4 53.7	11 4 53.7	RES = -0.97 SEC
ASD	IPG	11 4 53.7	11 4 53.7	RES = 0.28 SEC
ASD	IS	11 4 55.9	11 4 55.9	RES = 0.91 SEC
ASB	IPG	11 4 52.7	11 4 52.7	RES = -0.39 SEC

Table II-13 (Contd)

OCT 3, 1969
H = 13 49 2.0
LATITUDE = 51.462 N
LONGITUDE = 179.993 E
DEPTH = 36 KM
NUMBER OF PHASES USED = 15 STANDARD DEVIATION = 0.75 SEC

		CORR. TIME	RAW TIME		
SC3	EP	13 49 13.7	13 49 13.3	RES =	-0.97 SEC
SC3	ES	13 49 25.3	13 49 24.5	RES =	1.28 SEC
SC6	EP	13 49 14.4	13 49 14.2	RES =	-0.61 SEC
SC5	EP	13 49 20.4	13 49 20.1	RES =	0.81 SEC
SC5	ES	13 49 32.7	13 49 32.2	RES =	0.28 SEC
ASD	IPG	13 49 11.1	13 49 11.1	RES =	-0.67 SEC
ASD	IS	13 49 19.5	13 49 19.5	RES =	0.62 SEC
ASB	IPG	13 49 12.0	13 49 12.0	RES =	-0.66 SEC
ASB	IS	13 49 20.8	13 49 20.8	RES =	0.37 SEC
ASC	IPG	13 49 12.6	13 49 12.6	RES =	-0.69 SEC
ASC	IS	13 49 21.6	13 49 21.6	RES =	0.08 SEC
ANA	IPG	13 49 16.9	13 49 16.9	RES =	-1.05 SEC
ANA	IS	13 49 29.3	13 49 29.4	RES =	-0.20 SEC
SSI	IPG	13 49 13.8	13 49 13.9	RES =	0.79 SEC
SSI	IS	13 49 22.2	13 49 22.3	RES =	1.08 SEC

OCT 3, 1969
H = 14 52 36.9
LATITUDE = 51.439 N
LONGITUDE = 179.262 E
DEPTH = 8 KM
NUMBER OF PHASES USED = 9 STANDARD DEVIATION = 0.66 SEC

		CORR. TIME	RAW TIME		
SC6	EP	14 52 45.2	14 52 45.0	RES =	0.05 SEC
SC5	EP	14 52 47.9	14 52 47.6	RES =	-0.16 SEC
SC5	ES	14 52 56.5	14 52 56.0	RES =	0.31 SEC
ASC	IPG	14 52 38.6	14 52 38.6	RES =	-0.71 SEC
ASC	IS	14 52 40.0	14 52 40.0	RES =	-1.04 SEC
ASD	IPG	14 52 40.0	14 52 40.0	RES =	0.69 SEC
ASD	IS	14 52 42.0	14 52 42.0	RES =	0.95 SEC
ASB	IPG	14 52 39.0	14 52 39.0	RES =	-0.44 SEC
ASB	IS	14 52 40.5	14 52 40.5	RES =	-0.78 SEC

Table II-13 (Contd)

OCT 3, 1969
H = 13 52 38.4
LATITUDE = 51.455 N
LONGITUDE = 179.245 E
DEPTH = 9 KM
NUMBER OF PHASES USED = 9 STANDARD DEVIATION = 0.67 SEC

		CORR. TIME	RAW TIME		
SO8	+IP	13 52 44.7	13 52 44.4	RES =	0.74 SEC
SO6	EP	13 52 46.6	13 52 46.4	RES =	0.32 SEC
SO5	ES	13 52 58.0	13 52 57.5	RES =	1.06 SEC
SO3	+IP	13 52 48.3	13 52 47.9	RES =	-0.18 SEC
SO5	-EP	13 52 49.1	13 52 48.8	RES =	0.01 SEC
ASC	IPG	13 52 39.8	13 52 39.8	RES =	-0.96 SEC
ANA	IPG	13 52 46.7	13 52 46.7	RES =	-0.71 SEC
ASD	IPG	13 52 41.1	13 52 41.1	RES =	-0.14 SEC
ASB	IPG	13 52 40.4	13 52 40.4	RES =	-0.88 SEC

OCT 3, 1969
H = 15 46 40,7
LATITUDE = 51,940 N
LONGITUDE = 178,082 E
DEPTH = 116 KM
NUMBER OF PHASES USED = 11 STANDARD DEVIATION = ,34 SEC

		CORR, TIME	RAW TIME		
S06	EP	15 46 59,4	15 46 59,2	RES =	-,14 SEC
S05	-IP	15 46 59,9	15 46 59,6	RES =	,25 SEC
S05	ES	15 47 13,1	15 47 12,6	RES =	-,41 SEC
S08	EP	15 47 4,4	15 47 4,1	RES =	,70 SEC
S03	EP	15 47 5,0	15 47 4,5	RES =	-,33 SEC
ASD	IPG	15 47 1,9	15 47 1,9	RES =	-,37 SEC
ASB	IPG	15 47 1,7	15 47 1,7	RES =	-,28 SEC
ASC	IPG	15 47 1,0	15 47 1,0	RES =	,02 SEC
ASC	IS	15 47 16,2	15 47 16,2	RES =	,38 SEC
ANA	IPG	15 46 58,4	15 46 58,4	RES =	,07 SEC
SSI	IPG	15 47 1,9	15 47 2,0	RES =	-,28 SEC

Table II-13 (Contd)

OCT 3, 1969
H = 19 16 46.4
LATITUDE = 51.417 N
LONGITUDE = 179.243 E
DEPTH = 5 KM
NUMBER OF PHASES USED = 8 STANDARD DEVIATION = 0.61 SEC

		CORR. TIME	RAW TIME	
SC6	EP	19 16 54.9	19 16 54.7	RES = -0.17 SEC
SC6	ES	19 17 1.7	19 17 1.4	RES = 0.37 SEC
SC5	ES	19 17 5.7	19 17 5.2	RES = 0.04 SEC
ASC	IPG	19 16 47.7	19 16 47.7	RES = -0.92 SEC
ASC	IS	19 16 49.2	19 16 49.2	RES = -0.92 SEC
ASD	IPG	19 16 48.9	19 16 48.9	RES = 0.32 SEC
ASD	IS	19 16 51.0	19 16 51.0	RES = 0.99 SEC
ASB	IPG	19 16 48.1	19 16 48.1	RES = -0.30 SEC

OCT 3, 1969
H = 19 34 7.4
LATITUDE = 51.430 N
LONGITUDE = 179.202 E
DEPTH = 6 KM
NUMBER OF PHASES USED = 10 STANDARD DEVIATION = 0.63 SEC

		CORR. TIME	RAW TIME	
SC8	+IP	19 34 13.2	19 34 12.9	RES = -0.01 SEC
SC8	ES	19 34 18.4	19 34 17.8	RES = 0.85 SEC
SC6	EP	19 34 15.3	19 34 15.1	RES = -0.33 SEC
SC6	ES	19 34 22.3	19 34 22.0	RES = 0.71 SEC
SC5	EP	19 34 17.9	19 34 17.6	RES = -0.14 SEC
SC5	ES	19 34 26.0	19 34 25.5	RES = 0.30 SEC
ASC	IPG	19 34 8.4	19 34 8.4	RES = -0.86 SEC
ASC	IS	19 34 9.9	19 34 9.9	RES = -0.68 SEC
ASD	IPG	19 34 9.5	19 34 9.5	RES = -0.57 SEC
ASB	IPG	19 34 8.8	19 34 8.8	RES = -0.98 SEC

Table II-13 (Contd)

OCT 3, 1969
H = 20 8 50.4
LATITUDE = 51.409 N
LONGITUDE = 179.232 E
DEPTH = 5 KM
NUMBER OF PHASES USED = 9 STANDARD DEVIATION = 0.55 SEC

		CORR. TIME	RAW TIME		
SC6	EP	20 8 59.2	20 8 59.0	RES =	0.12 SEC
SC6	ES	20 9 5.4	20 9 5.1	RES =	-0.07 SEC
SC5	EP	20 9 1.2	20 9 0.9	RES =	-0.15 SEC
SC5	ES	20 9 9.6	20 9 9.1	RES =	0.30 SEC
ASC	IPG	20 8 51.7	20 8 51.7	RES =	-0.82 SEC
ASC	IS	20 8 53.2	20 8 53.2	RES =	-0.84 SEC
ASD	IPG	20 8 52.8	20 8 52.8	RES =	0.26 SEC
ASD	IS	20 8 55.0	20 8 55.0	RES =	1.01 SEC
ASB	IPG	20 8 51.8	20 8 51.8	RES =	-0.36 SEC

OCT 4, 1969
H = 6 34 3.6
LATITUDE = 51.436 N
LONGITUDE = 179.202 E
DEPTH = 5 KM
NUMBER OF PHASES USED = 10 STANDARD DEVIATION = 0.61 SEC

		CORR. TIME	RAW TIME		
SC6	EP	6 34 11.3	6 34 11.1	RES =	-0.38 SEC
SC6	ES	6 34 18.3	6 34 18.0	RES =	0.76 SEC
SC8	ES	6 34 14.5	6 34 13.9	RES =	0.77 SEC
SC5	EP	6 34 14.2	6 34 13.9	RES =	-0.05 SEC
SC5	ES	6 34 22.3	6 34 21.8	RES =	0.27 SEC
SC3	ES	6 34 21.4	6 34 20.6	RES =	0.02 SEC
ASC	IPG	6 34 4.5	6 34 4.5	RES =	-0.68 SEC
ASC	IS	6 34 6.0	6 34 6.0	RES =	-0.32 SEC
ASD	IPG	6 34 5.6	6 34 5.6	RES =	-0.61 SEC
ASB	IPG	6 34 4.7	6 34 4.7	RES =	-1.16 SEC

Table II-13 (Contd)

OCT 4, 1969
H = 7 33 14.8
LATITUDE = 51.420 N
LONGITUDE = 179.309 E
DEPTH = 50 KM
NUMBER OF PHASES USED = 6 STANDARD DEVIATION = 0.30 SEC

		CORR. TIME	RAW TIME		
SC8	EP	7 33 23.4	7 33 23.1	RES =	0.07 SEC
SC8	ES	7 33 29.3	7 33 28.7	RES =	-0.34 SEC
SC6	EP	7 33 25.3	7 33 25.1	RES =	0.13 SEC
SC6	ES	7 33 32.2	7 33 31.9	RES =	-0.48 SEC
SC5	EP	7 33 26.6	7 33 26.3	RES =	-0.31 SEC
SC5	ES	7 33 36.0	7 33 35.5	RES =	0.27 SEC

OCT 4, 1969
H = 8 3 25.3
LATITUDE = 51.176 N
LONGITUDE = 178.760 E
DEPTH = 30 KM
NUMBER OF PHASES USED = 9 STANDARD DEVIATION = 0.20 SEC

		CORR. TIME	RAW TIME		
SC5	-IP	8 3 32.4	8 3 32.1	RES =	0.23 SEC
SC3	+IP	8 3 34.6	8 3 34.2	RES =	-0.06 SEC
SC8	+IP	8 3 37.0	8 3 36.7	RES =	0.28 SEC
SC6	EP	8 3 38.5	8 3 38.3	RES =	0.26 SEC
ASC	IPG	8 3 34.3	8 3 34.3	RES =	0.21 SEC
ASD	IPG	8 3 34.5	8 3 34.5	RES =	-0.23 SEC
ANA	IPG	8 3 35.0	8 3 35.0	RES =	-0.22 SEC
ASB	IPG	8 3 33.8	8 3 33.8	RES =	0.04 SEC
SSI	IPG	8 3 42.3	8 3 42.4	RES =	-0.05 SEC

Table II-13 (Contd)

OCT 4, 1969
H = 8 41 57.0
LATITUDE = 51.382 N
LONGITUDE = 179.049 E
DEPTH = 2 KM
NUMBER OF PHASES USED = 6 STANDARD DEVIATION = 0.18 SEC

		CORR. TIME	RAW TIME	
SC6	ES	8 42 10.3	8 42 9.7	RES = 0.01 SEC
S08	EP	8 42 4.6	8 42 4.3	RES = -0.02 SEC
ASC	IPG	8 41 59.8	8 41 59.8	RES = 0.15 SEC
ASC	IS	8 42 1.2	8 42 1.2	RES = -0.38 SEC
ASD	IPG	8 42 1.1	8 42 1.1	RES = -0.20 SEC
ASB	IPG	8 42 0.1	8 42 0.1	RES = 0.03 SEC

OCT 4, 1969
H = 9 6 25.3
LATITUDE = 51.419 N
LONGITUDE = 179.168 E
DEPTH = 2 KM
NUMBER OF PHASES USED = 8 STANDARD DEVIATION = 0.42 SEC

		CORR. TIME	RAW TIME	
SC8	IP	9 6 31.4	9 6 31.1	RES = -0.02 SEC
SC6	EP	9 6 33.4	9 6 33.2	RES = -0.24 SEC
SC6	ES	9 6 40.6	9 6 40.3	RES = 0.91 SEC
S05	+EP	9 6 35.6	9 6 35.3	RES = 0.22 SEC
ASC	IPG	9 6 26.5	9 6 26.5	RES = -0.16 SEC
ANA	IPG	9 6 33.3	9 6 33.3	RES = -0.50 SEC
ASD	IPG	9 6 27.7	9 6 27.7	RES = -0.37 SEC
ASB	IPG	9 6 27.0	9 6 27.0	RES = -0.31 SEC

Table II-13 (Contd)

OCT 4, 1969
H = 22 14 31.9
LATITUDE = 51.248 N
LONGITUDE = 178.944 E
DEPTH = 40 KM
NUMBER OF PHASES USED = 13 STANDARD DEVIATION = 0.51 SEC

		CORR. TIME	RAW TIME	
SC5	-EP	22 14 41.3	22 14 41.0	RES = 0.61 SEC
SC8	-IP	22 14 42.1	22 14 41.8	RES = 0.04 SEC
SC8	ES	22 14 50.1	22 14 49.5	RES = 0.67 SEC
SC6	+IP	22 14 44.0	22 14 43.8	RES = 0.22 SEC
SC6	ES	22 14 53.0	22 14 52.7	RES = 0.66 SEC
SSI	IPG	22 14 46.6	22 14 46.7	RES = -0.30 SEC
SSI	IS	22 14 58.2	22 14 58.3	RES = 0.25 SEC
ASC	IPG	22 14 39.9	22 14 39.9	RES = -0.22 SEC
ASC	IS	22 14 45.8	22 14 45.8	RES = -0.26 SEC
ANA	IPG	22 14 41.9	22 14 41.9	RES = -0.13 SEC
ANA	IS	22 14 48.1	22 14 48.2	RES = -1.20 SEC
ASD	IPG	22 14 40.1	22 14 40.1	RES = -0.38 SEC
ASB	IPG	22 14 39.3	22 14 39.3	RES = -0.52 SEC

OCT 5, 1969
H = 10 22 43.5
LATITUDE = 51.197 N
LONGITUDE = 178.866 E
DEPTH = 24 KM
NUMBER OF PHASES USED = 9 STANDARD DEVIATION = 0.18 SEC

		CORR. TIME	RAW TIME	
SC5	ES	10 22 55.5	10 22 55.0	RES = -0.19 SEC
SC6	EP	10 22 55.6	10 22 55.4	RES = -0.09 SEC
SC6	ES	10 23 4.5	10 23 4.2	RES = -0.02 SEC
ASC	IPG	10 22 51.6	10 22 51.6	RES = -0.06 SEC
ASD	IS	10 22 57.1	10 22 57.1	RES = -0.48 SEC
ASB	IPG	10 22 50.7	10 22 50.7	RES = 0.03 SEC
ASB	ES	10 22 55.9	10 22 55.9	RES = 0.02 SEC
ASC	EPG	10 22 51.2	10 22 51.2	RES = 0.04 SEC
ASC	IS	10 22 56.7	10 22 56.7	RES = -0.03 SEC

Table II-13 (Contd)

OCT 5, 1969
H = 16 31 16.4
LATITUDE = 51.171 N
LONGITUDE = 179.345 E
DEPTH = 24 KM
NUMBER OF PHASES USED = 11 STANDARD DEVIATION = 1.11 SEC

		CORR. TIME	RAW TIME		
ASD	IPG	16 31 22.8	16 31 22.8	RES =	.22 SEC
ASD	IS	16 31 24.3	16 31 24.3	RES =	-2.76 SEC
ASB	IPG	16 31 22.7	16 31 22.7	RES =	.38 SEC
ASB	IS	16 31 24.5	16 31 24.5	RES =	-2.11 SEC
ASC	IPG	16 31 24.0	16 31 24.0	RES =	.08 SEC
SSI	IPG	16 31 30.6	16 31 30.7	RES =	-.36 SEC
S08	IP	16 31 23.5	16 31 23.2	RES =	.55 SEC
S08	ES	16 31 28.4	16 31 27.8	RES =	.62 SEC
S05	E(P)	16 31 27.7	16 31 27.4	RES =	-.28 SEC
S05	ES	16 31 36.5	16 31 36.0	RES =	.11 SEC
S06	ES	16 31 38.7	16 31 38.4	RES =	.60 SEC

OCT 5, 1969
H = 20 59 17.5
LATITUDE = 51.363 N
LONGITUDE = 178.852 E
DEPTH = 45 KM
NUMBER OF PHASES USED = 16 STANDARD DEVIATION = 0.55 SEC

		CORR. TIME	RAW TIME		
S05	+IP	20 59 26.4	20 59 26.1	RES =	0.18 SEC
S05	ES	20 59 33.3	20 59 32.8	RES =	0.90 SEC
S08	-IP	20 59 28.4	20 59 28.1	RES =	-0.10 SEC
S08	ES	20 59 37.1	20 59 36.5	RES =	0.65 SEC
S06	EP	20 59 28.6	20 59 28.4	RES =	0.18 SEC
S06	ES	20 59 37.1	20 59 36.8	RES =	0.81 SEC
S03	EP	20 59 28.8	20 59 28.4	RES =	-0.02 SEC
ASD	IPG	20 59 26.4	20 59 26.4	RES =	-0.39 SEC
ASB	IPG	20 59 25.7	20 59 25.7	RES =	-0.50 SEC
ASB	IS	20 59 32.1	20 59 32.1	RES =	-0.35 SEC
ASC	IPG	20 59 25.7	20 59 25.7	RES =	-0.24 SEC
ASC	IS	20 59 31.8	20 59 31.8	RES =	-0.21 SEC
ANA	IPG	20 59 26.3	20 59 26.3	RES =	-0.33 SEC
ANA	IS	20 59 31.6	20 59 31.7	RES =	-1.45 SEC
SSI	IPG	20 59 31.8	20 59 31.9	RES =	-0.11 SEC
SSI	IS	20 59 42.3	20 59 42.4	RES =	-0.13 SEC

Table II-13 (Contd)

OCT 5, 1969
H = 21 11 10.2
LATITUDE = 51.814 N
LONGITUDE = 178.450 E
DEPTH = 136 KM
NUMBER OF PHASES USED = 7 STANDARD DEVIATION = 0.31 SEC

		CORR. TIME	RAW TIME	
SC6	ES	21 11 43.6	21 11 43.3	RES = -0.31 SEC
SC5	ES	21 11 44.6	21 11 44.1	RES = -0.09 SEC
ASD	IPG	21 11 31.2	21 11 31.2	RES = -0.27 SEC
ASD	IS	21 11 46.8	21 11 46.8	RES = -0.21 SEC
ASB	EPG	21 11 31.4	21 11 31.4	RES = 0.21 SEC
ASB	ES	21 11 47.3	21 11 47.3	RES = 0.62 SEC
SC6	EP	21 11 29.9	21 11 29.7	RES = 0.23 SEC

OCT 5, 1969
H = 21 17 47.2
LATITUDE = 51.174 N
LONGITUDE = 178.798 E
DEPTH = 20 KM
NUMBER OF PHASES USED = 11 STANDARD DEVIATION = 0.51 SEC

		CORR. TIME	RAW TIME	
SC5	+EP	21 17 53.7	21 17 53.4	RES = 0.10 SEC
SC5	ES	21 17 58.8	21 17 58.3	RES = 0.59 SEC
SC6	EP	21 17 59.7	21 17 59.5	RES = -0.08 SEC
SC6	ES	21 18 9.6	21 18 9.3	RES = 0.60 SEC
ASD	IPG	21 17 56.0	21 17 56.0	RES = 0.10 SEC
ASB	IPG	21 17 55.2	21 17 55.2	RES = 0.33 SEC
ASD	IS	21 18 0.1	21 18 0.1	RES = -0.36 SEC
ASC	EPG	21 17 55.7	21 17 55.7	RES = 0.38 SEC
ASC	ES	21 18 1.2	21 18 1.2	RES = -0.02 SEC
ANA	EPG	21 17 56.2	21 17 56.2	RES = -0.62 SEC
ASC	IS	21 18 1.1	21 18 1.1	RES = -1.17 SEC

OCT 6, 1969
H = 8 43 51.1
LATITUDE = 51.600 N
LONGITUDE = 179.030 E
DEPTH = 118 KM
NUMBER OF PHASES USED = 9 STANDARD DEVIATION = 0.66 SEC

		CORR. TIME	RAW TIME		
SC8	EP	8 44 9.4	8 44 9.1	RES =	0.81 SEC
SC8	ES	8 44 20.5	8 44 19.9	RES =	-0.98 SEC
SC6	ES	8 44 19.6	8 44 19.3	RES =	-0.19 SEC
ASD	EPG	8 44 7.2	8 44 7.2	RES =	-0.80 SEC
ASD	ES	8 44 20.4	8 44 20.4	RES =	0.04 SEC
ASB	EPG	8 44 7.6	8 44 7.6	RES =	-0.35 SEC
ASB	ES	8 44 20.7	8 44 20.7	RES =	0.43 SEC
ASC	EPG	8 44 7.5	8 44 7.5	RES =	-0.10 SEC
ASC	ES	8 44 20.8	8 44 20.8	RES =	1.12 SEC

OCT 6, 1969
H = 18 5 4.9
LATITUDE = 51.545 N
LONGITUDE = 179.107 E
DEPTH = 63 KM
NUMBER OF PHASES USED = 15 STANDARD DEVIATION = 0.75 SEC

		CORR. TIME	RAW TIME		
SC6	EP	18 5 15.4	18 5 15.2	RES =	0.18 SEC
SC6	ES	18 5 24.0	18 5 23.7	RES =	1.30 SEC
SC8	EP	18 5 16.2	18 5 15.9	RES =	0.23 SEC
S08	ES	18 5 25.3	18 5 24.7	RES =	1.16 SEC
SC5	EP	18 5 17.2	18 5 16.9	RES =	0.16 SEC
SC5	ES	18 5 26.4	18 5 25.9	RES =	0.51 SEC
ASD	IPG	18 5 14.7	18 5 14.7	RES =	-0.33 SEC
ASD	IS	18 5 20.6	18 5 20.6	RES =	-1.82 SEC
ASB	IPG	18 5 14.7	18 5 14.7	RES =	-0.28 SEC
ASB	IS	18 5 21.8	18 5 21.8	RES =	-0.53 SEC
ANA	IPG	18 5 15.1	18 5 15.1	RES =	-0.47 SEC
ANA	IS	18 5 22.4	18 5 22.5	RES =	-0.86 SEC
SSI	IPG	18 5 16.7	18 5 16.8	RES =	-0.53 SEC
SSI	IS	18 5 26.6	18 5 26.7	RES =	0.29 SEC
ASC	IS	18 5 21.5	18 5 21.5	RES =	-0.02 SEC

Table II-13 (Contd)

OCT 6, 1969
H = 18 49 37.5
LATITUDE = 52.002 N
LONGITUDE = 178.206 E
DEPTH = 141 KM
NUMBER OF PHASES USED = 15 STANDARD DEVIATION = 0.50 SEC

		CORR. TIME	RAW TIME	
SC5	EP	18 49 59.9	18 49 59.6	RES = 0.44 SEC
SC5	ES	18 50 15.4	18 50 14.9	RES = 0.06 SEC
SC6	EP	18 49 58.9	18 49 58.7	RES = 0.21 SEC
SC6	ES	18 50 14.8	18 50 14.5	RES = 0.72 SEC
SC8	EP	18 50 2.8	18 50 2.5	RES = 0.38 SEC
SC8	ES	18 50 21.5	18 50 20.9	RES = 0.82 SEC
SC3	EP	18 50 4.0	18 50 3.6	RES = -0.14 SEC
ASB	IPG	18 50 0.9	18 50 0.9	RES = -0.19 SEC
ASC	IPG	18 49 59.9	18 49 59.9	RES = -0.28 SEC
ASC	ES	18 50 16.9	18 50 16.9	RES = 0.25 SEC
ANA	IPG	18 49 58.0	18 49 58.0	RES = -0.00 SEC
ANA	IS	18 50 11.9	18 50 12.0	RES = -0.96 SEC
SSI	IPG	18 50 0.5	18 50 0.6	RES = -0.24 SEC
ASD	IPG	18 50 1.1	18 50 1.1	RES = -0.19 SEC
ASD	IS	18 50 17.6	18 50 17.6	RES = -0.97 SEC

OCT 6, 1969
H = 21 40 49.7
LATITUDE = 51.208 N
LONGITUDE = 179.432 E
DEPTH = 22 KM
NUMBER OF PHASES USED = 13 STANDARD DEVIATION = 0.74 SEC

		CORR. TIME	RAW TIME	
SC3	EP	21 40 54.9	21 40 54.5	RES = -0.87 SEC
SC8	EP	21 40 55.7	21 40 55.4	RES = 0.39 SEC
SC8	ES	21 41 1.3	21 41 0.7	RES = 1.89 SEC
SC6	EP	21 41 1.6	21 41 1.4	RES = -0.35 SEC
SC6	ES	21 41 11.4	21 41 11.1	RES = 0.57 SEC
SC5	+EP	21 41 2.7	21 41 2.4	RES = 0.67 SEC
SC5	ES	21 41 9.8	21 41 9.3	RES = -1.12 SEC
ASD	IPG	21 40 55.2	21 40 55.2	RES = -0.22 SEC
ASD	IS	21 40 59.6	21 40 59.6	RES = 0.06 SEC
ASB	IPG	21 40 55.1	21 40 55.1	RES = -0.35 SEC
ASC	IPG	21 40 56.6	21 40 56.6	RES = -0.50 SEC
SSI	IPG	21 41 3.2	21 41 3.3	RES = -0.32 SEC
SSI	IS	21 41 13.7	21 41 13.8	RES = 0.06 SEC

Table II-13 (Contd)

OCT 7, 1969
H = 2 10 8.5
LATITUDE = 51.302 N
LONGITUDE = 178.816 E
DEPTH = 31 KM
NUMBER OF PHASES USED = 13 STANDARD DEVIATION = 1.03 SEC

		CORR. TIME	RAW TIME	
S05	-IP	2 10 15.1	2 10 14.8	RES = -0.20 SEC
SC3	IP	2 10 17.3	2 10 16.9	RES = -1.17 SEC
SC6	EP	2 10 20.0	2 10 19.8	RES = 0.66 SEC
S06	E(S)	2 10 29.4	2 10 29.1	RES = 2.09 SEC
SC8	E(P)	2 10 21.0	2 10 20.7	RES = 2.15 SEC
SC8	E(S)	2 10 27.0	2 10 26.4	RES = 0.40 SEC
ASD	IPG	2 10 16.2	2 10 16.2	RES = -0.53 SEC
ASB	IPG	2 10 15.5	2 10 15.5	RES = -0.37 SEC
ASC	IPG	2 10 15.7	2 10 15.7	RES = -0.06 SEC
ASC	IS	2 10 22.1	2 10 22.1	RES = 0.93 SEC
ANA	IPG	2 10 16.2	2 10 16.2	RES = -0.53 SEC
SSI	IPG	2 10 22.7	2 10 22.8	RES = -0.76 SEC
SSI	IS	2 10 33.8	2 10 33.9	RES = -0.77 SEC

OCT 7, 1969
H = 2 36 39.0
LATITUDE = 51.265 N
LONGITUDE = 178.806 E
DEPTH = 39 KM
NUMBER OF PHASES USED = 10 STANDARD DEVIATION = 0.24 SEC

		CORR. TIME	RAW TIME	
SC5	-EP	2 36 47.0	2 36 46.7	RES = 0.26 SEC
SC5	ES	2 36 52.5	2 36 52.0	RES = 0.12 SEC
SC3	EP	2 36 49.0	2 36 48.6	RES = -0.30 SEC
ASD	IPG	2 36 48.2	2 36 48.2	RES = -0.04 SEC
ASD	IS	2 36 55.0	2 36 55.0	RES = 0.03 SEC
ASB	IPG	2 36 47.5	2 36 47.5	RES = 0.03 SEC
ASC	IPG	2 36 47.5	2 36 47.5	RES = -0.01 SEC
ANA	IPG	2 36 48.1	2 36 48.1	RES = -0.34 SEC
ANA	IS	2 36 54.7	2 36 54.8	RES = -0.53 SEC
SSI	IPG	2 36 54.4	2 36 54.5	RES = -0.03 SEC

Table II-13 (Contd)

OCT 7, 1969
H = 12 2 36.8
LATITUDE = 51.183 N
LONGITUDE = 178.863 E
DEPTH = 22 KM
NUMBER OF PHASES USED = 6 STANDARD DEVIATION = 0.90 SEC

		CORR. TIME	RAW TIME	
SC5	E(P)	12 2 44.5	12 2 44.2	RES = 0.79 SEC
SC5	ES	12 2 47.0	12 2 46.5	RES = -1.75 SEC
SC6	E(P)	12 2 48.8	12 2 48.6	RES = -0.29 SEC
ASB	IPG	12 2 43.3	12 2 43.3	RES = -0.61 SEC
ASB	IS	12 2 49.9	12 2 49.9	RES = 0.80 SEC
SC6	ES	12 2 58.4	12 2 58.1	RES = 0.37 SEC

OCT 7, 1969
H = 13 31 20.9
LATITUDE = 51.125 N
LONGITUDE = 179.923 E
DEPTH = 28 KM
NUMBER OF PHASES USED = 9 STANDARD DEVIATION = 0.37 SEC

		CORR. TIME	RAW TIME	
SC6	EP	13 31 37.2	13 31 37.0	RES = 0.49 SEC
SC5	EP	13 31 38.7	13 31 38.4	RES = 0.38 SEC
SC5	ES	13 31 51.3	13 31 50.8	RES = 0.25 SEC
ASD	IPG	13 31 30.5	13 31 30.5	RES = -0.09 SEC
ASB	IPG	13 31 30.9	13 31 30.9	RES = -0.20 SEC
ASC	IPG	13 31 32.5	13 31 32.5	RES = -0.19 SEC
ANA	EPG	13 31 37.6	13 31 37.6	RES = -0.73 SEC
SSI	IPG	13 31 36.1	13 31 36.2	RES = -0.13 SEC
SSI	IS	13 31 47.9	13 31 48.0	RES = 0.38 SEC

Table II-13 (Contd)

OCT 7, 1969
H = 22 12 42.3
LATITUDE = 51.198 N
LONGITUDE = 179.955 E
DEPTH = 25 KM
NUMBER OF PHASES USED = 9 STANDARD DEVIATION = 0.50 SEC

		CORR. TIME	RAW TIME		
SC8	+IP	22 12 50.5	22 12 50.2	RES =	1.25 SEC
S03	-IP	22 12 51.6	22 12 51.2	RES =	0.11 SEC
SC6	+IP	22 12 58.0	22 12 57.8	RES =	0.61 SEC
SC5	-EP	22 12 59.8	22 12 59.5	RES =	-0.04 SEC
ASD	IPG	22 12 51.4	22 12 51.4	RES =	-0.17 SEC
ASB	IPG	22 12 51.9	22 12 51.9	RES =	-0.34 SEC
ASC	IPG	22 12 53.6	22 12 53.6	RES =	-0.13 SEC
ANA	IPG	22 12 59.5	22 12 59.5	RES =	0.11 SEC
SSI	IPG	22 12 56.1	22 12 56.2	RES =	-0.39 SEC

OCT 8, 1969
H = 10 8 5,4
LATITUDE = 50,943 N
LONGITUDE = 178,476 E
DEPTH = 40 KM
NUMBER OF PHASES USED = 13 STANDARD DEVIATION = 1,16 SEC

		CORR, TIME	RAW TIME		
S05	+IP	10 8 14,4	10 8 14,1	RES =	-,45 SEC
S05	ES	10 8 22,3	10 8 21,8	RES =	,52 SEC
S03	E(P)	10 8 17,9	10 8 17,5	RES =	,70 SEC
S03	ES	10 8 28,1	10 8 27,3	RES =	2,14 SEC
S08	EP	10 8 20,6	10 8 20,3	RES =	-,18 SEC
S08	E(S)	10 8 32,7	10 8 32,1	RES =	,56 SEC
S06	EP	10 8 22,3	10 8 22,1	RES =	-,07 SEC
S06	ES	10 8 36,6	10 8 36,3	RES =	1,84 SEC
ASD	IPG	10 8 18,0	10 8 18,0	RES =	-1,25 SEC
ASD	IS	10 8 27,9	10 8 27,9	RES =	-1,48 SEC
ASB	IPG	10 8 17,1	10 8 17,1	RES =	-1,26 SEC
ASB	IS	10 8 26,2	10 8 26,2	RES =	-1,66 SEC
SSI	IPG	10 8 26,1	10 8 26,2	RES =	,05 SEC

Table II-13 (Contd)

OCT 8, 1969
H = 11 42 45,2
LATITUDE = 51,440 N
LONGITUDE = 178,717 E
DEPTH = 29 KM
NUMBER OF PHASES USED = 9 STANDARD DEVIATION = ,45 SEC

		CORR, TIME	RAW TIME		
S05	+IP	11 42 51,6	11 42 51,3	RES =	,11 SEC
S08	IP	11 42 57,0	11 42 56,7	RES =	,55 SEC
S06	+IP	11 42 55,0	11 42 54,8	RES =	,46 SEC
S03	-IP	11 42 57,1	11 42 56,7	RES =	-,19 SEC
SSI	IPG	11 42 59,1	11 42 59,2	RES =	-,23 SEC
ASC	IPG	11 42 52,7	11 42 52,7	RES =	,31 SEC
ANA	IPG	11 42 51,0	11 42 51,0	RES =	-,37 SEC
ASD	IPG	11 42 53,2	11 42 53,2	RES =	-,86 SEC
ASB	IPG	11 42 53,8	11 42 53,8	RES =	,52 SEC

OCT 8, 1969
H = 20 51 43.4
LATITUDE = 51.702 N
LONGITUDE = 179.824 E
DEPTH = 88 KM
NUMBER OF PHASES USED = 15 STANDARD DEVIATION = 0.64 SEC

		CORR. TIME	RAW TIME		
SC8	EP	20 51 57.6	20 51 57.3	RES =	0.34 SEC
SC8	ES	20 52 7.7	20 52 7.1	RES =	0.33 SEC
S06	+IP	20 51 58.3	20 51 58.1	RES =	0.42 SEC
S06	ES	20 52 9.7	20 52 9.4	RES =	1.33 SEC
SC5	EP	20 52 2.7	20 52 2.4	RES =	0.11 SEC
SC5	ES	20 52 16.9	20 52 16.4	RES =	0.41 SEC
SC3	ES	20 52 14.5	20 52 13.7	RES =	0.98 SEC
ASD	IPG	20 51 57.3	20 51 57.3	RES =	-0.50 SEC
ASD	IS	20 52 7.6	20 52 7.6	RES =	-0.60 SEC
ASB	IPG	20 51 57.9	20 51 57.9	RES =	-0.36 SEC
ASB	IS	20 52 8.0	20 52 8.0	RES =	-1.00 SEC
ANA	IPG	20 52 0.1	20 52 0.1	RES =	-0.31 SEC
ANA	IS	20 52 12.4	20 52 12.5	RES =	-0.27 SEC
ASC	EPG	20 51 57.8	20 51 57.8	RES =	-0.35 SEC
ASC	IS	20 52 7.9	20 52 7.9	RES =	-0.89 SEC

Table II-13 (Contd)

OCT 9, 1969
H = 2 9 28.7
LATITUDE = 51.482 N
LONGITUDE = 178.786 E
DEPTH = 61 KM
NUMBER OF PHASES USED = 15 STANDARD DEVIATION = 0.74 SEC

		CORR. TIME	RAW TIME	
SO5	EP	2 9 39.2	2 9 38.9	RES = 0.32 SEC
SC5	ES	2 9 46.9	2 9 46.4	RES = 0.57 SEC
SC6	EP	2 9 40.0	2 9 39.8	RES = 0.28 SEC
SC6	ES	2 9 49.4	2 9 49.1	RES = 1.66 SEC
SC8	EP	2 9 41.7	2 9 41.4	RES = 0.53 SEC
SO8	ES	2 9 51.3	2 9 50.7	RES = 0.92 SEC
SC3	E(P)	2 9 42.4	2 9 42.0	RES = 0.19 SEC
SC3	E(S)	2 9 51.0	2 9 50.2	RES = -1.21 SEC
ASD	IPG	2 9 39.3	2 9 39.3	RES = -0.36 SEC
ASD	IS	2 9 47.4	2 9 47.4	RES = -0.27 SEC
ASB	IPG	2 9 38.8	2 9 38.8	RES = -0.46 SEC
SSI	IPG	2 9 42.4	2 9 42.5	RES = -0.54 SEC
SSI	IS	2 9 53.2	2 9 53.3	RES = -0.26 SEC
ANA	IPG	2 9 37.3	2 9 37.3	RES = -1.05 SEC
ANA	IS	2 9 44.7	2 9 44.8	RES = -0.62 SEC

OCT 9, 1969
H = 3 54 26.6
LATITUDE = 51.722 N
LONGITUDE = 178.890 E
DEPTH = 71 KM
NUMBER OF PHASES USED = 13 STANDARD DEVIATION = 0.91 SEC

		CORR. TIME	RAW TIME	
SC6	EP	3 54 37.9	3 54 37.7	RES = 0.44 SEC
SC6	ES	3 54 46.9	3 54 46.6	RES = 1.56 SEC
SC8	EP	3 54 40.7	3 54 40.4	RES = 0.23 SEC
SC8	ES	3 54 51.4	3 54 50.8	RES = 0.72 SEC
SC5	EP	3 54 39.8	3 54 39.5	RES = 0.06 SEC
SC5	ES	3 54 49.5	3 54 49.0	RES = 0.18 SEC
SC3	E(S)	3 54 56.4	3 54 55.6	RES = 1.37 SEC
ASD	IPG	3 54 38.3	3 54 38.3	RES = -0.99 SEC
ASD	IS	3 54 47.1	3 54 47.1	RES = -1.45 SEC
ASB	IPG	3 54 38.2	3 54 38.2	RES = -0.99 SEC
ASB	IS	3 54 47.2	3 54 47.2	RES = -1.18 SEC
ANA	IPG	3 54 37.4	3 54 37.4	RES = -0.19 SEC
ANA	IS	3 54 45.3	3 54 45.4	RES = -0.21 SEC

Table II-13 (Contd)

OCT 9, 1969
H = 13 16 44.6
LATITUDE = 51.535 N
LONGITUDE = 179.582 W
DEPTH = 70 KM
NUMBER OF PHASES USED = 11 STANDARD DEVIATION = 0.36 SEC

		CORR. TIME	RAW TIME	
SC8	EP	13 16 58.5	13 16 58.2	RES = 0.36 SEC
SC8	ES	13 17 8.7	13 17 8.1	RES = 0.61 SEC
ASD	IPG	13 16 59.3	13 16 59.3	RES = -0.45 SEC
ASD	IS	13 17 10.2	13 17 10.2	RES = -0.58 SEC
ASB	IPG	13 17 0.3	13 17 0.3	RES = -0.18 SEC
ASB	IS	13 17 11.9	13 17 11.9	RES = -0.14 SEC
ASC	IPG	13 17 0.5	13 17 0.5	RES = -0.41 SEC
ANA	IPG	13 17 4.9	13 17 4.9	RES = 0.11 SEC
ANA	IS	13 17 19.4	13 17 19.5	RES = -0.02 SEC
SSI	IPG	13 16 58.9	13 16 59.0	RES = -0.07 SEC
SSI	IS	13 17 9.2	13 17 9.3	RES = -0.32 SEC

OCT 9, 1969
H = 23 11 0.9
LATITUDE = 51.616 N
LONGITUDE = 179.153 W
DEPTH = 72 KM
NUMBER OF PHASES USED = 9 STANDARD DEVIATION = 0.62 SEC

		CORR. TIME	RAW TIME	
SSI	EPG	23 11 17.7	23 11 17.8	RES = 0.09 SEC
SSI	ES	23 11 29.1	23 11 29.2	RES = -0.72 SEC
SC8	EP	23 11 17.7	23 11 17.4	RES = 0.02 SEC
SC8	ES	23 11 29.1	23 11 28.5	RES = -0.83 SEC
SC6	EP	23 11 20.7	23 11 20.5	RES = -0.33 SEC
SC6	ES	23 11 37.1	23 11 36.8	RES = 1.36 SEC
SC3	E(P)	23 11 21.5	23 11 21.1	RES = 0.06 SEC
SC3	E(S)	23 11 36.8	23 11 36.0	RES = 0.32 SEC
SC5	ES	23 11 44.9	23 11 44.4	RES = -0.43 SEC

Table II-13 (Contd)

OCT 10, 1969
H = 8 19 36.2
LATITUDE = 50.960 N
LONGITUDE = 179.207 E
DEPTH = 20 KM
NUMBER OF PHASES USED = 11 STANDARD DEVIATION = 1.41 SEC

		CORR. TIME	RAW TIME		
ASD	IPG	8 19 44.3	8 19 44.3	RES =	-1.15 SEC
ASB	IPG	8 19 44.0	8 19 44.0	RES =	-0.84 SEC
ASB	IS	8 19 49.6	8 19 49.6	RES =	-1.55 SEC
SC3	EP	8 19 41.8	8 19 41.4	RES =	1.30 SEC
SC3	ES	8 19 47.5	8 19 46.7	RES =	3.74 SEC
SC8	EP	8 19 45.5	8 19 45.2	RES =	-0.46 SEC
S08	ES	8 19 52.9	8 19 52.3	RES =	-0.29 SEC
SC5	+EP	8 19 47.5	8 19 47.2	RES =	-0.38 SEC
SC5	ES	8 19 56.4	8 19 55.9	RES =	-0.01 SEC
SC6	EP	8 19 52.0	8 19 51.8	RES =	0.17 SEC
SC6	ES	8 20 4.3	8 20 4.0	RES =	1.09 SEC

OCT 10, 1969
H = 8 22 18,5
LATITUDE = 51,570 N
LONGITUDE = 179,539 E
DEPTH = 72 KM
NUMBER OF PHASES USED = 14 STANDARD DEVIATION = ,77 SEC

		CORR, TIME	RAW TIME		
ASD	IPG	8 22 29,0	8 22 29,0	RES =	-,79 SEC
ASD	IS	8 22 37,1	8 22 37,1	RES =	-,92 SEC
ASB	IPG	8 22 29,4	8 22 29,4	RES =	-,71 SEC
ASB	IS	8 22 37,5	8 22 37,5	RES =	-1,09 SEC
SSI	IPG	8 22 30,7	8 22 30,8	RES =	,17 SEC
ASC	IPG	8 22 29,6	8 22 29,6	RES =	-,41 SEC
S08	IP	8 22 30,0	8 22 29,7	RES =	,32 SEC
S08	ES	8 22 39,0	8 22 38,4	RES =	1,07 SEC
S06	EP	8 22 30,6	8 22 30,4	RES =	,03 SEC
S06	ES	8 22 39,6	8 22 39,3	RES =	,26 SEC
S03	EP	8 22 32,0	8 22 31,6	RES =	-,76 SEC
S03	ES	8 22 45,0	8 22 44,2	RES =	1,71 SEC
S05	EP	8 22 34,5	8 22 34,2	RES =	,33 SEC
S05	ES	8 22 45,4	8 22 44,9	RES =	-,19 SEC

Table II-13 (Contd)

OCT 10, 1969
H = 8 54 16.4
LATITUDE = 50.958 N
LONGITUDE = 179.590 E
DEPTH = 27 KM
NUMBER OF PHASES USED = 12 STANDARD DEVIATION = 1.61 SEC

		CORR. TIME	RAW TIME	
ASD	IPG	8 54 25.8	8 54 25.8	RES = -0.54 SEC
ASD	IS	8 54 30.7	8 54 30.7	RES = -2.82 SEC
ASB	IPG	8 54 25.5	8 54 25.5	RES = -0.78 SEC
ASB	IS	8 54 30.2	8 54 30.2	RES = -3.22 SEC
SC3	EP	8 54 23.6	8 54 23.2	RES = 1.53 SEC
SC3	ES	8 54 27.4	8 54 26.6	RES = 1.15 SEC
SC8	-IP	8 54 26.5	8 54 26.2	RES = 1.00 SEC
SC8	ES	8 54 32.2	8 54 31.6	RES = 0.03 SEC
SC5	E(P)	8 54 31.1	8 54 30.8	RES = -0.58 SEC
SC5	E(S)	8 54 43.7	8 54 43.2	RES = 0.95 SEC
SC6	EP	8 54 32.3	8 54 32.1	RES = -0.80 SEC
SC6	ES	8 54 47.5	8 54 47.2	RES = 2.31 SEC

OCT 10, 1969
H = 18 20 45.7
LATITUDE = 51.113 N
LONGITUDE = 179.222 E
DEPTH = 34 KM
NUMBER OF PHASES USED = 11 STANDARD DEVIATION = 0.94 SEC

		CORR. TIME	RAW TIME	
SC3	EP	18 20 52.6	18 20 52.2	RES = 0.44 SEC
SC3	ES	18 20 59.0	18 20 58.2	RES = 2.00 SEC
SC5	EP	18 20 56.6	18 20 56.3	RES = -0.30 SEC
SC5	ES	18 21 5.0	18 21 4.5	RES = 0.08 SEC
SC6	EP	18 20 59.5	18 20 59.2	RES = 0.20 SEC
SC6	ES	18 21 10.6	18 21 10.3	RES = 1.41 SEC
ASD	IPG	18 20 52.9	18 20 52.9	RES = -0.74 SEC
ASB	IPG	18 20 52.5	18 20 52.5	RES = -0.65 SEC
ASB	IS	18 20 57.0	18 20 57.0	RES = -1.56 SEC
SSI	IPG	18 21 1.4	18 21 1.5	RES = -0.05 SEC
SSI	IS	18 21 12.9	18 21 13.0	RES = -0.16 SEC

Table II-13 (Contd)

OCT 10, 1969
H = 21 31 5.6
LATITUDE = 51.736 N
LONGITUDE = 179.374 W
DEPTH = 95 KM
NUMBER OF PHASES USED = 11 STANDARD DEVIATION = 0.64 SEC

		CORR. TIME	RAW TIME	
ASD	IPG	21 31 24.0	21 31 24.0	RES = -0.69 SEC
ASB	IPG	21 31 24.7	21 31 24.7	RES = -0.71 SEC
ASB	IS	21 31 38.6	21 31 38.6	RES = -1.24 SEC
SC8	+IP	21 31 23.4	21 31 23.1	RES = 0.07 SEC
SC8	ES	21 31 36.3	21 31 35.7	RES = 0.02 SEC
SC3	EP	21 31 27.2	21 31 26.8	RES = 0.11 SEC
SC3	ES	21 31 44.0	21 31 43.2	RES = 1.18 SEC
SC6	EP	21 31 25.9	21 31 25.7	RES = 0.48 SEC
SC6	ES	21 31 40.4	21 31 40.1	RES = 0.54 SEC
SC5	E(P)	21 31 31.1	21 31 30.8	RES = 0.07 SEC
SC5	ES	21 31 49.2	21 31 48.7	RES = -0.24 SEC

OCT 11, 1969
H = 4 51 3,5
LATITUDE = 51,715 N
LONGITUDE = 178,470 E
DEPTH = 82 KM
NUMBER OF PHASES USED = 14 STANDARD DEVIATION = ,73 SEC

		CORR, TIME	RAW TIME	
S06	EP	4 51 17,1	4 51 16,9	RES = ,12 SEC
S06	ES	4 51 27,8	4 51 27,5	RES = 1,00 SEC
S05	EP	4 51 16,8	4 51 16,5	RES = -,15 SEC
S05	ES	4 51 27,1	4 51 26,6	RES = ,32 SEC
S08	-IP	4 51 21,3	4 51 21,0	RES = ,80 SEC
S08	ES	4 51 34,6	4 51 34,0	RES = 1,57 SEC
S03	EP	4 51 21,8	4 51 21,3	RES = -,30 SEC
S03	ES	4 51 34,8	4 51 34,0	RES = -,85 SEC
ASD	IPG	4 51 18,7	4 51 18,7	RES = -,30 SEC
ASD	IS	4 51 29,9	4 51 29,9	RES = -,42 SEC
ASB	IPG	4 51 18,3	4 51 18,3	RES = -,37 SEC
ASB	IS	4 51 29,5	4 51 29,5	RES = -,27 SEC
SSI	EPG	4 51 19,7	4 51 19,8	RES = -,35 SEC
SSI	IS	4 51 30,9	4 51 31,0	RES = -1,34 SEC

Table II-13 (Contd)

OCT 11, 1969
H = 16 29 12.2
LATITUDE = 50.862 N
LONGITUDE = 179.270 E
DEPTH = 35 KM
NUMBER OF PHASES USED = 7 STANDARD DEVIATION = 0.99 SEC

		CORR. TIME	RAW TIME		
SC3	EP	16 29 19.5	16 29 19.1	RES =	0.88 SEC
SC3	ES	16 29 24.4	16 29 23.6	RES =	1.00 SEC
SC8	EP	16 29 23.7	16 29 23.4	RES =	0.01 SEC
SC8	ES	16 29 30.3	16 29 29.7	RES =	-1.85 SEC
SC6	E(P)	16 29 29.1	16 29 28.9	RES =	-0.18 SEC
SC6	E(S)	16 29 42.8	16 29 42.5	RES =	1.10 SEC
SC5	ES	16 29 35.1	16 29 34.6	RES =	-0.64 SEC

OCT 11, 1969
H = 20 42 23.8
LATITUDE = 51.048 N
LONGITUDE = 179.564 E
DEPTH = 22 KM
NUMBER OF PHASES USED = 6 STANDARD DEVIATION = 0.39 SEC

		CORR. TIME	RAW TIME		
SC3	EP	20 42 28.4	20 42 28.0	RES =	-0.35 SEC
SC8	+IP	20 42 31.5	20 42 31.2	RES =	0.30 SEC
SC6	EP	20 42 39.1	20 42 38.9	RES =	0.22 SEC
SC6	ES	20 42 49.4	20 42 49.1	RES =	-0.46 SEC
SC5	EP	20 42 37.8	20 42 37.5	RES =	-0.26 SEC
SC5	ES	20 42 49.0	20 42 48.5	RES =	0.61 SEC

Table II-13 (Contd)

OCT 11, 1969
H = 23 2 46.5
LATITUDE = 52.001 N
LONGITUDE = 177.757 E
DEPTH = 109 KM
NUMBER OF PHASES USED = 9 STANDARD DEVIATION = 0.88 SEC

		CORR. TIME	RAW TIME	
ASD	IPG	23 3 8.3	23 3 8.3	RES = -1.46 SEC
ASD	IS	23 3 25.7	23 3 25.7	RES = -0.94 SEC
SO6	EP	23 3 6.1	23 3 5.9	RES = -0.48 SEC
SO6	ES	23 3 22.3	23 3 22.0	RES = 1.12 SEC
SO5	EP	23 3 5.9	23 3 5.6	RES = -0.25 SEC
SO5	ES	23 3 21.4	23 3 20.9	RES = 1.02 SEC
SO8	EP	23 3 12.5	23 3 12.2	RES = 1.18 SEC
SO8	ES	23 3 29.5	23 3 28.9	RES = -0.03 SEC
SO3	ES	23 3 32.0	23 3 31.2	RES = 0.04 SEC

OCT 11, 1969
H = 23 29 ,1
LATITUDE = 51,200 N
LONGITUDE = 178,545 E
DEPTH = 12 KM
NUMBER OF PHASES USED = 12 STANDARD DEVIATION = 1,05 SEC

		CORR, TIME	RAW TIME	
ASD	IPG	23 29 10,1	23 29 10,1	RES = -,95 SEC
ASD	IS	23 29 17,2	23 29 17,2	RES = -1,81 SEC
ASB	IPG	23 29 9,4	23 29 9,4	RES = -,56 SEC
ASB	IS	23 29 15,3	23 29 15,3	RES = -1,83 SEC
SSI	IPG	23 29 17,6	23 29 17,7	RES = -,69 SEC
SSI	IS	23 29 33,0	23 29 33,1	RES = 1,37 SEC
SO5	IP	23 29 5,2	23 29 4,9	RES = 1,18 SEC
SO3	EP	23 29 12,2	23 29 11,8	RES = ,88 SEC
SO8	EP	23 29 13,6	23 29 13,3	RES = ,24 SEC
SO8	ES	23 29 23,6	23 29 23,0	RES = ,49 SEC
SO6	EP	23 29 13,4	23 29 13,2	RES = -,13 SEC
SO6	ES	23 29 24,0	23 29 23,7	RES = ,73 SEC

Table II-13 (Contd)

OCT 12, 1969
H = 20 58 26.3
LATITUDE = 51.217 N
LONGITUDE = 179.947 W
DEPTH = 120 KM
NUMBER OF PHASES USED = 6 STANDARD DEVIATION = 0.23 SEC

		CORR. TIME	RAW TIME		
SC8	EP	20 58 43.7	20 58 43.4	RES =	0.04 SEC
SC3	EP	20 58 44.3	20 58 43.9	RES =	-0.23 SEC
SC3	ES	20 58 58.3	20 58 57.5	RES =	0.42 SEC
SC6	EP	20 58 47.1	20 58 46.9	RES =	0.01 SEC
SC5	EP	20 58 49.0	20 58 48.7	RES =	0.17 SEC
SC5	ES	20 59 4.9	20 59 4.4	RES =	-0.26 SEC

OCT 13, 1969
H = 6 16 19.2
LATITUDE = 51.592 N
LONGITUDE = 179.158 E
DEPTH = 21 KM
NUMBER OF PHASES USED = 6 STANDARD DEVIATION = 0.81 SEC

		CORR. TIME	RAW TIME		
SC6	EP	6 16 23.6	6 16 23.4	RES =	-1.21 SEC
SC6	ES	6 16 30.4	6 16 30.1	RES =	1.49 SEC
ASD	IPG	6 16 25.3	6 16 25.3	RES =	0.03 SEC
ASD	IS	6 16 29.4	6 16 29.4	RES =	-0.33 SEC
ASB	IPG	6 16 25.4	6 16 25.4	RES =	0.05 SEC
ASB	IS	6 16 29.5	6 16 29.5	RES =	-0.37 SEC

Table II-13 (Contd)

OCT 13, 1969
H = 6 51 18.7
LATITUDE = 51.149 N
LONGITUDE = 178.134 E
DEPTH = 34 KM
NUMBER OF PHASES USED = 10 STANDARD DEVIATION = 1.57 SEC

		CORR. TIME	RAW TIME	
ASD	IPG	6 51 32.3	6 51 32.3	RES = -1.59 SEC
ASD	IS	6 51 45.1	6 51 45.1	RES = 0.15 SEC
ASB	IPG	6 51 31.4	6 51 31.4	RES = -1.55 SEC
ASB	IS	6 51 44.7	6 51 44.7	RES = 1.37 SEC
SC5	+EP	6 51 25.6	6 51 25.3	RES = -0.67 SEC
SC5	ES	6 51 34.4	6 51 33.9	RES = 2.64 SEC
SC8	EP	6 51 35.8	6 51 35.5	RES = -0.12 SEC
SC8	ES	6 51 50.9	6 51 50.3	RES = 2.34 SEC
SO6	E(P)	6 51 36.3	6 51 36.1	RES = 1.17 SEC
SC6	ES	6 51 45.2	6 51 44.9	RES = -1.87 SEC

OCT 13, 1969
H = 12 1 46.0
LATITUDE = 52.007 N
LONGITUDE = 178.007 E
DEPTH = 76 KM
NUMBER OF PHASES USED = 9 STANDARD DEVIATION = 0.84 SEC

		CORR. TIME	RAW TIME	
SC5	EP	12 2 1.9	12 2 1.6	RES = -0.24 SEC
SC5	ES	12 2 15.4	12 2 14.9	RES = 1.48 SEC
SC8	EP	12 2 8.5	12 2 8.2	RES = 1.22 SEC
SC8	ES	12 2 23.2	12 2 22.6	RES = 0.27 SEC
SC3	E(S)	12 2 26.0	12 2 25.2	RES = -0.23 SEC
ASD	IPG	12 2 4.5	12 2 4.5	RES = -1.05 SEC
ASD	IS	12 2 19.7	12 2 19.7	RES = -0.13 SEC
ASB	IPG	12 2 4.0	12 2 4.0	RES = -1.20 SEC
ASB	IS	12 2 19.2	12 2 19.2	RES = -0.04 SEC

Table II-13 (Contd)

OCT 13, 1969
H = 19 35 2.9
LATITUDE = 51.037 N
LONGITUDE = 179.[illegible]35 W
DEPTH = 24 KM
NUMBER OF PHASES USED = 6 STANDARD DEVIATION = 0.10 SEC

		CORR. TIME	RAW TIME	
SC5	EP	19 35 22.2	19 35 21.9	RES = -0.01 SEC
SC5	ES	19 35 36.1	19 35 35.6	RES = -0.11 SEC
ASD	IPG	19 35 14.4	19 35 14.4	RES = -0.19 SEC
ASB	IPG	19 35 15.2	19 35 15.2	RES = 0.12 SEC
SSI	IPG	19 35 20.0	19 35 20.1	RES = -0.05 SEC
SSI	IS	19 35 32.6	19 35 32.7	RES = 0.01 SEC

OCT 14, 1969
H = 17 2 29.5
LATITUDE = 51.072 N
LONGITUDE = 179.839 W
DEPTH = 29 KM
NUMBER OF PHASES USED = 7 STANDARD DEVIATION = 0.54 SEC

		CORR. TIME	RAW TIME	
SC8	EP	17 2 40.5	17 2 40.2	RES = 1.04 SEC
SC8	ES	17 2 46.1	17 2 45.5	RES = -0.66 SEC
SC6	ES	17 3 1.1	17 3 0.8	RES = 0.48 SEC
ASD	EPG	17 2 41.5	17 2 41.5	RES = -0.22 SEC
ASB	EP	17 2 41.9	17 2 41.9	RES = -0.40 SEC
SSI	EPG	17 2 46.4	17 2 46.5	RES = -0.08 SEC
SSI	IS	17 2 58.7	17 2 58.8	RES = -0.21 SEC

Table II-13 (Contd)

OCT 15, 1969
H = 6 19 14.6
LATITUDE = 51.392 N
LONGITUDE = 178.921 E
DEPTH = 57 KM
NUMBER OF PHASES USED = 14 STANDARD DEVIATION = 0.48 SEC

		CORR. TIME	RAW TIME		
SC8	EP	6 19 26.2	6 19 25.9	RES =	0.39 SEC
SC8	ES	6 19 34.9	6 19 34.3	RES =	0.84 SEC
SC5	-EP	6 19 24.5	6 19 24.2	RES =	-0.22 SEC
SC5	-ES	6 19 32.3	6 19 31.8	RES =	0.24 SEC
SC6	EP	6 19 26.0	6 19 25.8	RES =	0.21 SEC
SC6	ES	6 19 34.4	6 19 34.1	RES =	0.51 SEC
ASB	IPG	6 19 23.7	6 19 23.7	RES =	-0.37 SEC
ASB	IS	6 19 30.0	6 19 30.0	RES =	-0.95 SEC
ASC	IPG	6 19 23.7	6 19 23.7	RES =	-0.15 SEC
ASC	IS	6 19 30.2	6 19 30.2	RES =	-0.36 SEC
ASD	IPG	6 19 24.0	6 19 24.0	RES =	-0.46 SEC
ASD	IS	6 19 31.0	6 19 31.0	RES =	-0.62 SEC
SSI	IPG	6 19 28.4	6 19 28.5	RES =	-0.35 SEC
SSI	IS	6 19 38.8	6 19 38.9	RES =	-0.33 SEC

OCT 15, 1969
H = 15 43 35.8
LATITUDE = 51.361 N
LONGITUDE = 178.818 E
DEPTH = 39 KM
NUMBER OF PHASES USED = 6 STANDARD DEVIATION = 0.09 SEC

		CORR. TIME	RAW TIME		
SC6	EP	15 43 46.3	15 43 46.1	RES =	-0.09 SEC
SC6	ES	15 43 54.1	15 43 53.8	RES =	0.02 SEC
SC5	E(S)	15 43 49.1	15 43 48.6	RES =	-0.07 SEC
ASB	EPG	15 43 44.0	15 43 44.0	RES =	0.06 SEC
ASD	IPG	15 43 44.6	15 43 44.6	RES =	-0.04 SEC
ASD	IS	15 43 50.9	15 43 50.9	RES =	-0.19 SEC

Table II-13 (Contd)

OCT 16, 1969
H = 1 14 32.0
LATITUDE = 51.548 N
LONGITUDE = 178.268 E
DEPTH = 79 KM
NUMBER OF PHASES USED = 12 STANDARD DEVIATION = 0.72 SEC

		CORR. TIME	RAW TIME		
SC5	EP	1 14 43.7	1 14 43.4	RES =	-0.52 SEC
SC5	ES	1 14 52.3	1 14 51.8	RES =	-0.84 SEC
SC6	E(P)	1 14 47.9	1 14 47.7	RES =	1.25 SEC
SC6	ES	1 14 57.0	1 14 56.7	RES =	-0.32 SEC
ASC	EPG	1 14 46.3	1 14 46.3	RES =	-0.22 SEC
ASB	IPG	1 14 46.8	1 14 46.8	RES =	-0.48 SEC
ASB	IS	1 14 59.3	1 14 59.3	RES =	0.84 SEC
ASD	IPG	1 14 47.6	1 14 47.6	RES =	-0.20 SEC
ASD	IS	1 14 59.7	1 14 59.7	RES =	0.35 SEC
SSI	IPG	1 14 50.0	1 14 50.1	RES =	-0.30 SEC
SSI	IS	1 15 2.7	1 15 2.8	RES =	-1.07 SEC
ASC	ES	1 14 58.2	1 14 58.2	RES =	1.06 SEC

OCT 16, 1969
H = 4 13 35,4
LATITUDE = 51,297 N
LONGITUDE = 178,140 E
DEPTH = 42 KM
NUMBER OF PHASES USED = 8 STANDARD DEVIATION = ,60 SEC

		CORR, TIME	RAW TIME		
SO5	IP	4 13 43,4	4 13 43,1	RES =	,13 SEC
SO6	EP	4 13 50,3	4 13 50,1	RES =	-,02 SEC
SO8	EP	4 13 52,6	4 13 52,3	RES =	,49 SEC
ASB	IPG	4 13 48,2	4 13 48,2	RES =	-1,01 SEC
ASB	IS	4 13 60,0	4 14 ,0	RES =	,71 SEC
ASD	IPG	4 13 49,2	4 13 49,2	RES =	-,85 SEC
ASC	IPG	4 13 49,3	4 13 49,3	RES =	,61 SEC
SSI	IPG	4 13 54,7	4 13 54,8	RES =	-,09 SEC

Table II-13 (Contd)

OCT 17, 1969
H = 0 30 17.1
LATITUDE = 51.617 N
LONGITUDE = 179.618 W
DEPTH = 55 KM
NUMBER OF PHASES USED = 9 STANDARD DEVIATION = 0.70 SEC

		CORR. TIME	RAW TIME		
SC5	E(P)	0 30 38.8	0 30 38.5	RES =	0.40 SEC
SC5	ES	0 30 53.5	0 30 53.0	RES =	-0.49 SEC
SC3	ES	0 30 47.2	0 30 46.4	RES =	0.97 SEC
SSI	EPG	0 30 29.4	0 30 29.5	RES =	-0.12 SEC
SSI	IS	0 30 39.9	0 30 40.0	RES =	1.18 SEC
ASD	IPG	0 30 30.3	0 30 30.3	RES =	-0.87 SEC
ASD	IS	0 30 41.7	0 30 41.7	RES =	0.23 SEC
ASB	IPG	0 30 31.1	0 30 31.1	RES =	-0.89 SEC
ASB	IS	0 30 42.8	0 30 42.8	RES =	-0.10 SEC

Table II-14

NEAR-MILROW HYPOCENTER CALCULATIONS
USING MILROW RESIDUALS

OCT 2, 1969
H = 22 5 59.8
LATITUDE = 51.420 N
LONGITUDE = 179.204 E
DEPTH = 7 KM
NUMBER OF PHASES USED = 7 STANDARD DEVIATION = .05 SEC

		CORR. TIME	RAW TIME		
ASC	IPG	22 6 1.7	22 6 1.7	RES =	-.05 SEC
ASB	IPG	22 6 1.9	22 6 2.0	RES =	-.07 SEC
ANB	IPG	22 6 6.8	22 6 6.6	RES =	.04 SEC
SO8	+IP	22 6 5.6	22 6 5.8	RES =	.02 SEC
SO6	IP	22 6 8.2	22 6 8.0	RES =	-.01 SEC
SO3	EP	22 6 9.7	22 6 9.1	RES =	-.00 SEC
SO5	+IP	22 6 10.3	22 6 10.3	RES =	.08 SEC

OCT 3, 1969
H = 3 41 56.4
LATITUDE = 51.422 N
LONGITUDE = 179.206 E
DEPTH = 6 KM
NUMBER OF PHASES USED = 10 STANDARD DEVIATION = .50 SEC

		CORR. TIME	RAW TIME		
SO8	ES	3 42 7.3	3 42 6.7	RES =	.99 SEC
SO8	EP	3 42 1.7	3 42 1.9	RES =	-.36 SEC
SO6	E(P)	3 42 4.5	3 42 4.3	RES =	-.24 SEC
SO6	E(S)	3 42 11.3	3 42 11.0	RES =	.48 SEC
SO5	EP	3 42 7.0	3 42 7.0	RES =	-.03 SEC
SO5	ES	3 42 14.8	3 42 14.3	RES =	-.04 SEC
ASC	IPG	3 41 57.5	3 41 57.5	RES =	-.66 SEC
ASC	IS	3 41 58.9	3 41 58.9	RES =	-.60 SEC
ASD	IPG	3 41 58.7	3 41 58.7	RES =	-.18 SEC
ASB	IPG	3 41 57.9	3 41 58.0	RES =	-.53 SEC

Table II-14 (Contd)

OCT 3, 1969
H = 4 37 15.2
LATITUDE = 51.375 N
LONGITUDE = 179.138 E
DEPTH = 2 KM
NUMBER OF PHASES USED = 7 STANDARD DEVIATION = .47 SEC

		CORR. TIME	RAW TIME		
S08	EP	4 37 21.2	4 37 21.4	RES =	-.44 SEC
S08	ES	4 37 27.2	4 37 26.6	RES =	.76 SEC
ASC	IPG	4 37 17.0	4 37 17.0	RES =	-.45 SEC
ASC	IS	4 37 18.4	4 37 18.4	RES =	-.73 SEC
ANA	IPG	4 37 24.0	4 37 24.0	RES =	.04 SEC
ASD	IPG	4 37 18.3	4 37 18.3	RES =	-.05 SEC
ASB	IPG	4 37 17.2	4 37 17.3	RES =	.12 SEC

OCT 3, 1969
H = 6 17 58.3
LATITUDE = 51.432 N
LONGITUDE = 179.315 E
DEPTH = 11 KM
NUMBER OF PHASES USED = 9 STANDARD DEVIATION = .92 SEC

		CORR. TIME	RAW TIME		
S06	ES	6 18 14.0	6 18 13.7	RES =	1.11 SEC
S05	EP	6 18 9.5	6 18 9.5	RES =	.06 SEC
S05	ES	6 18 18.2	6 18 17.7	RES =	.55 SEC
ASC	IPG	6 18 .3	6 18 .3	RES =	-1.30 SEC
ANA	EPG	6 18 7.1	6 18 7.1	RES =	-.87 SEC
ASD	IPG	6 18 1.5	6 18 1.5	RES =	.63 SEC
ASD	IS	6 18 3.7	6 18 3.7	RES =	.92 SEC
ASB	IPG	6 18 .5	6 18 .6	RES =	-.76 SEC
ASB	IS	6 18 2.2	6 18 2.2	RES =	-1.36 SEC

Table II-14 (Contd)

OCT 3, 1969
H = 6 37 3,3
LATITUDE = 51,411 N
LONGITUDE = 179,213 E
DEPTH = 8 KM
NUMBER OF PHASES USED = 11 STANDARD DEVIATION = ,74 SEC

		CORR, TIME	RAW TIME	
ANA	EPG	6 37 11,4	6 37 11,4	RES = -1,05 SEC
SN6	EP	6 37 12,0	6 37 11,8	RES = ,07 SEC
SN6	ES	6 37 19,4	6 37 19,1	RES = 1,19 SEC
SN5	EP	6 37 13,8	6 37 13,8	RES = -,05 SEC
SN5	ES	6 37 22,5	6 37 22,0	RES = ,92 SEC
ASC	IPG	6 37 4,6	6 37 4,6	RES = -,87 SEC
ASC	IS	6 37 6,0	6 37 6,0	RES = -1,11 SEC
ASD	IPG	6 37 5,8	6 37 5,8	RES = -,09 SEC
ASD	IS	6 37 8,1	6 37 8,1	RES = ,34 SEC
ASB	IPG	6 37 4,9	6 37 5,0	RES = -,50 SEC
ASB	IS	6 37 6,5	6 37 6,5	RES = -,50 SEC

OCT 3, 1969
H = 6 39 2,7
LATITUDE = 51,401 N
LONGITUDE = 179,225 E
DEPTH = 5 KM
NUMBER OF PHASES USED = 9 STANDARD DEVIATION = ,58 SEC

		CORR, TIME	RAW TIME	
SN6	EP	6 39 11,8	6 39 11,6	RES = ,22 SEC
SN6	ES	6 39 17,7	6 39 17,4	RES = -,32 SEC
SN5	EP	6 39 13,2	6 39 13,2	RES = -,36 SEC
SN5	ES	6 39 21,9	6 39 21,4	RES = ,39 SEC
ASC	IPG	6 39 4,1	6 39 4,1	RES = -,80 SEC
ASC	IS	6 39 5,5	6 39 5,5	RES = -1,05 SEC
ASD	IPG	6 39 5,1	6 39 5,1	RES = ,23 SEC
ASD	IS	6 39 7,3	6 39 7,3	RES = ,88 SEC
ASB	IPG	6 39 4,2	6 39 4,3	RES = -,13 SEC

Table II-14 (Contd)

OCT 3, 1969
H = 7 6 3.1
LATITUDE = 51.422 N
LONGITUDE = 179.288 E
DEPTH = 9 KM
NUMBER OF PHASES USED = 9 STANDARD DEVIATION = .94 SEC

		CORR. TIME	RAW TIME	
S06	ES	7 6 18.3	7 6 18.0	RES = .14 SEC
S05	EP	7 6 14.1	7 6 14.1	RES = -.27 SEC
S05	ES	7 6 22.9	7 6 22.4	RES = .30 SEC
ASC	IPG	7 6 4.9	7 6 4.9	RES = -1.08 SEC
ASC	IS	7 6 6.4	7 6 6.4	RES = -1.72 SEC
ASD	IPG	7 6 6.2	7 6 6.2	RES = .87 SEC
ASD	IS	7 6 8.5	7 6 8.5	RES = 1.57 SEC
ASB	IPG	7 6 5.2	7 6 5.3	RES = -.40 SEC
ASB	IS	7 6 7.0	7 6 7.0	RES = -.48 SEC

OCT 3, 1969
H = 7 10 44.9
LATITUDE = 51.429 N
LONGITUDE = 179.284 E
DEPTH = 9 KM
NUMBER OF PHASES USED = 8 STANDARD DEVIATION = .90 SEC

		CORR. TIME	RAW TIME	
S06	ES	7 10 59.8	7 10 59.5	RES = .11 SEC
S05	EP	7 10 55.8	7 10 55.8	RES = -.24 SEC
S05	ES	7 11 4.5	7 11 4.0	RES = .30 SEC
ASC	IPG	7 10 46.6	7 10 46.6	RES = -1.10 SEC
ASC	IS	7 10 48.1	7 10 48.1	RES = -1.71 SEC
ASD	IPG	7 10 48.0	7 10 48.0	RES = .72 SEC
ASD	IS	7 10 50.2	7 10 50.2	RES = 1.20 SEC
ASB	IPG	7 10 47.1	7 10 47.2	RES = -.40 SEC

Table II-14 (Contd)

OCT 3, 1969
H = 7 35 52.4
LATITUDE = 51.458 N
LONGITUDE = 179.184 E
DEPTH = 6 KM
NUMBER OF PHASES USED = 11 STANDARD DEVIATION = .72 SEC

		CORR. TIME	RAW TIME	
SO6	EP	7 36 .0	7 35 59.8	RES = .06 SEC
SO8	EP	7 35 58.9	7 35 59.1	RES = .36 SEC
SO8	ES	7 36 3.6	7 36 3.0	RES = .44 SEC
SO5	EP	7 36 2.4	7 36 2.4	RES = -.48 SEC
SO5	ES	7 36 11.6	7 36 11.1	RES = 1.00 SEC
ASC	IPG	7 35 53.8	7 35 53.8	RES = -.01 SEC
ASC	IS	7 35 55.1	7 35 55.1	RES = .19 SEC
ASD	IPG	7 35 54.3	7 35 54.3	RES = -1.13 SEC
ASD	IS	7 35 56.0	7 35 56.0	RES = -1.66 SEC
ASB	IPG	7 35 55.0	7 35 55.1	RES = -.09 SEC
ASB	IS	7 35 57.4	7 35 57.4	RES = .24 SEC

OCT 3, 1969
H = 7 40 31.6
LATITUDE = 51.454 N
LONGITUDE = 179.204 E
DEPTH = 6 KM
NUMBER OF PHASES USED = 11 STANDARD DEVIATION = .54 SEC

		CORR. TIME	RAW TIME	
SO6	E(S)	7 40 45.0	7 40 44.6	RES = .04 SEC
SO8	EP	7 40 37.4	7 40 37.6	RES = -.08 SEC
SO8	ES	7 40 42.8	7 40 42.2	RES = .91 SEC
SO5	EP	7 40 42.1	7 40 42.1	RES = -.24 SEC
SO5	ES	7 40 50.8	7 40 50.3	RES = .57 SEC
ASC	IPG	7 40 32.9	7 40 32.9	RES = -.18 SEC
ASC	IS	7 40 34.3	7 40 34.3	RES = .07 SEC
ASD	IPG	7 40 34.1	7 40 34.1	RES = -.29 SEC
ASD	IS	7 40 36.4	7 40 36.4	RES = -.02 SEC
ASB	IPG	7 40 33.3	7 40 33.4	RES = -.84 SEC
ASB	IS	7 40 35.0	7 40 35.0	RES = -1.08 SEC

Table II-14 (Contd)

OCT 3, 1969
H = 8 18 51,8
LATITUDE = 51,426 N
LONGITUDE = 179,186 E
DEPTH = 8 KM
NUMBER OF PHASES USED = 12 STANDARD DEVIATION = 1,17 SEC

		CORR, TIME	RAW TIME		
S08	*IP	8 18 57,2	8 18 57,4	RES =	-,68 SEC
S08	ES	8 19 4,1	8 19 3,5	RES =	1,65 SEC
S06	EP	8 18 59,4	8 18 59,2	RES =	-,75 SEC
S06	ES	8 19 8,8	8 19 8,5	RES =	2,56 SEC
S05	*EP	8 19 2,2	8 19 2,2	RES =	,19 SEC
S05	ES	8 19 10,6	8 19 10,1	RES =	1,10 SEC
ASC	IPG	8 18 53,0	8 18 53,0	RES =	-,80 SEC
ASC	IS	8 18 54,5	8 18 54,5	RES =	-,83 SEC
ANA	IPG	8 18 59,3	8 18 59,3	RES =	-1,20 SEC
ASD	IPG	8 18 54,1	8 18 54,1	RES =	-,70 SEC
ASD	IS	8 18 56,1	8 18 56,1	RES =	-,88 SEC
ASB	IPG	8 18 53,3	8 18 53,4	RES =	-,94 SEC

OCT 3, 1969
H = 8 37 40,8
LATITUDE = 51,489 N
LONGITUDE = 179,238 E
DEPTH = 3 KM
NUMBER OF PHASES USED = 8 STANDARD DEVIATION = ,64 SEC

		CORR, TIME	RAW TIME		
S06	EP	8 37 47,8	8 37 47,6	RES =	-,10 SEC
S05	ES	8 38 ,6	8 38 ,1	RES =	-,11 SEC
ASC	IPG	8 37 42,9	8 37 42,9	RES =	,36 SEC
ASC	IS	8 37 44,3	8 37 44,3	RES =	,50 SEC
ASD	IPG	8 37 44,2	8 37 44,2	RES =	,40 SEC
ASD	IS	8 37 46,5	8 37 46,5	RES =	,60 SEC
ASB	IPG	8 37 43,2	8 37 43,3	RES =	-,78 SEC
ASB	IS	8 37 45,0	8 37 45,0	RES =	-1,32 SEC

OCT 3, 1969
H = 10 40 16,4
LATITUDE = 51,453 N
LONGITUDE = 179,254 E
DEPTH = 7 KM
NUMBER OF PHASES USED = 8 STANDARD DEVIATION = ,51 SEC

		CORR, TIME	RAW TIME		
SO5	EP	10 40 27,5	10 40 27,5	RES =	-,05 SEC
SO5	ES	10 40 35,9	10 40 35,4	RES =	,17 SEC
ASC	IPG	10 40 18,3	10 40 18,3	RES =	-,20 SEC
ASC	IS	10 40 19,9	10 40 19,9	RES =	-,20 SEC
ASD	IPG	10 40 19,4	10 40 19,4	RES =	,49 SEC
ASD	IS	10 40 21,6	10 40 21,6	RES =	,86 SEC
ASB	IPG	10 40 18,5	10 40 18,6	RES =	-,50 SEC
ASB	IS	10 40 20,1	10 40 20,1	RES =	-,88 SEC

OCT 3, 1969
H = 10 43 6,1
LATITUDE = 51,427 N
LONGITUDE = 179,239 E
DEPTH = 9 KM
NUMBER OF PHASES USED = 10 STANDARD DEVIATION = ,69 SEC

		CORR, TIME	RAW TIME		
SO6	EP	10 43 14,5	10 43 14,3	RES =	,00 SEC
SO6	ES	10 43 22,0	10 43 21,7	RES =	1,40 SEC
SO5	EP	10 43 16,8	10 43 16,8	RES =	-,11 SEC
SO5	ES	10 43 25,5	10 43 25,0	RES =	,67 SEC
ASC	IPG	10 43 7,5	10 43 7,5	RES =	-1,01 SEC
ASC	IS	10 43 8,8	10 43 8,8	RES =	-1,52 SEC
ASA	EPG	10 43 14,3	10 43 14,3	RES =	-1,13 SEC
ASD	IPG	10 43 8,7	10 43 8,7	RES =	,01 SEC
ASD	IS	10 43 11,0	10 43 11,0	RES =	,45 SEC
ASB	IPG	10 43 7,8	10 43 7,9	RES =	-,79 SEC

Table II-14 (Contd)

OCT 3, 1969
H = 11 4 51.2
LATITUDE = 51.415 N
LONGITUDE = 179.228 E
DEPTH = 5 KM
NUMBER OF PHASES USED = 8 STANDARD DEVIATION = .64 SEC

		CORR. TIME	RAW TIME		
S06	EP	11 4 59.6	11 4 59.4	RES =	-.19 SEC
S06	ES	11 5 6.4	11 5 6.1	RES =	.39 SEC
S05	ES	11 5 10.1	11 5 9.6	RES =	-.03 SEC
ASC	IPG	11 4 52.2	11 4 52.2	RES =	-.99 SEC
ASC	IS	11 4 53.7	11 4 53.7	RES =	-.97 SEC
ASD	IPG	11 4 53.7	11 4 53.7	RES =	.28 SEC
ASD	IS	11 4 55.9	11 4 55.9	RES =	.92 SEC
ASB	IPG	11 4 52.6	11 4 52.7	RES =	-.44 SEC

OCT 3, 1969
H = 11 40 22.5
LATITUDE = 51.390 N
LONGITUDE = 179.146 E
DEPTH = 4 KM
NUMBER OF PHASES USED = 8 STANDARD DEVIATION = .27 SEC

		CORR. TIME	RAW TIME		
S08	EP	11 40 28.6	11 40 28.8	RES =	-.27 SEC
S08	ES	11 40 34.1	11 40 33.5	RES =	.50 SEC
ASC	IPG	11 40 24.2	11 40 24.2	RES =	-.34 SEC
ASC	IS	11 40 25.7	11 40 25.7	RES =	-.36 SEC
ANA	IPG	11 40 31.2	11 40 31.2	RES =	.03 SEC
ASD	IPG	11 40 25.5	11 40 25.5	RES =	-.07 SEC
ASD	IS	11 40 27.7	11 40 27.7	RES =	-.07 SEC
ASB	IPG	11 40 24.6	11 40 24.7	RES =	.14 SEC

OCT 3, 1969
H = 13 52 38,3
LATITUDE = 51,457 N
LONGITUDE = 179,243 E
DEPTH = 9 KM
NUMBER OF PHASES USED = 9 STANDARD DEVIATION = ,62 SEC

		CORR, TIME	RAW TIME		
SO8	*IP	13 52 44,2	13 52 44,4	RES =	,29 SEC
SO6	EP	13 52 46,6	13 52 46,4	RES =	,44 SEC
SO5	ES	13 52 58,0	13 52 57,5	RES =	1,13 SEC
SO5	-EP	13 52 48,8	13 52 48,8	RES =	-,20 SEC
SO3	*IP	13 52 48,5	13 52 47,9	RES =	,02 SEC
ASC	IPG	13 52 39,9	13 52 39,8	RES =	-,83 SEC
ANA	IPG	13 52 46,7	13 52 46,7	RES =	-,60 SEC
ASD	IPG	13 52 41,1	13 52 41,1	RES =	-,09 SEC
ASB	IPG	13 52 40,3	13 52 40,4	RES =	-,89 SEC

OCT 3, 1969
H = 14 52 36,7
LATITUDE = 51,434 N
LONGITUDE = 179,291 E
DEPTH = 9 KM
NUMBER OF PHASES USED = 9 STANDARD DEVIATION = ,86 SEC

		CORR, TIME	RAW TIME		
SO6	EP	14 52 45,2	14 52 45,0	RES =	,07 SEC
SO5	EP	14 52 47,6	14 52 47,6	RES =	-,19 SEC
SO5	ES	14 52 56,5	14 52 56,0	RES =	,55 SEC
ASC	IPG	14 52 38,6	14 52 38,6	RES =	-,87 SEC
ASC	IS	14 52 40,0	14 52 40,0	RES =	-1,60 SEC
ASD	IPG	14 52 40,0	14 52 40,0	RES =	,91 SEC
ASD	IS	14 52 42,0	14 52 42,0	RES =	1,14 SEC
ASB	IPG	14 52 38,9	14 52 39,0	RES =	-,43 SEC
ASB	IS	14 52 40,5	14 52 40,5	RES =	-,87 SEC

Table II-14 (Contd)

OCT 3, 1969
H = 19 16 46,5
LATITUDE = 51.416 N
LONGITUDE = 179,243 E
DEPTH = 5 KM
NUMBER OF PHASES USED = 8 STANDARD DEVIATION = ,61 SEC

		CORR, TIME	RAW TIME		
S06	EP	19 16 54,9	19 16 54,7	RES =	-,17 SEC
S06	ES	19 17 1,7	19 17 1,4	RES =	,39 SEC
S05	ES	19 17 5,7	19 17 5,2	RES =	,04 SEC
ASC	IPG	19 16 47,7	19 16 47,7	RES =	-,87 SEC
ASC	IS	19 16 49,2	19 16 49,2	RES =	-,93 SEC
ASD	IPG	19 16 48,9	19 16 48,9	RES =	,35 SEC
ASD	IS	19 16 51,0	19 16 51,0	RES =	,97 SEC
ASB	IPG	19 16 48,0	19 16 48,1	RES =	-,30 SEC

OCT 3, 1969
H = 19 34 7,2
LATITUDE = 51,427 N
LONGITUDE = 179,218 E
DEPTH = 8 KM
NUMBER OF PHASES USED = 10 STANDARD DEVIATION = ,78 SEC

		CORR, TIME	RAW TIME		
S08	+IP	19 34 12,7	19 34 12,9	RES =	-,21 SEC
S08	ES	19 34 18,4	19 34 17,8	RES =	1,24 SEC
S06	EP	19 34 15,3	19 34 15,1	RES =	-,30 SEC
S06	ES	19 34 22,3	19 34 22,0	RES =	,61 SEC
S05	EP	19 34 17,6	19 34 17,6	RES =	-,23 SEC
S05	ES	19 34 26,0	19 34 25,5	RES =	,42 SEC
ASC	IPG	19 34 8,4	19 34 8,4	RES =	-1,06 SEC
ASC	IS	19 34 9,9	19 34 9,9	RES =	-1,23 SEC
ASD	IPG	19 34 9,5	19 34 9,5	RES =	-,46 SEC
ASB	IPG	19 34 8,7	19 34 8,8	RES =	-,99 SEC

Table II-14 (Contd)

OCT 3, 1969
H = 20 8 50,2
LATITUDE = 51.405 N
LONGITUDE = 179,252 E
DEPTH = 7 KM
NUMBER OF PHASES USED = 9 STANDARD DEVIATION = ,77 SEC

		CORR, TIME	RAW TIME	
S06	EP	20 8 59,2	20 8 59,0	RES = ,11 SEC
S06	ES	20 9 5,4	20 9 5,1	RES = -,17 SEC
S05	EP	20 9 ,9	20 9 ,9	RES = -,34 SEC
S05	ES	20 9 9,6	20 9 9,1	RES = ,26 SEC
ASC	IPG	20 8 51,7	20 8 51,7	RES = -1,03 SEC
ASC	IS	20 8 53,2	20 8 53,2	RES = -1,45 SEC
ASD	IPG	20 8 52,8	20 8 52,8	RES = ,52 SEC
ASD	IS	20 8 55,0	20 8 55,0	RES = 1,21 SEC
ASB	IPG	20 8 51,7	20 8 51,8	RES = -,41 SEC

OCT 4, 1969
H = 6 34 3,6
LATITUDE = 51.435 N
LONGITUDE = 179,199 E
DEPTH = 6 KM
NUMBER OF PHASES USED = 10 STANDARD DEVIATION = ,68 SEC

		CORR, TIME	RAW TIME	
S06	EP	6 34 11,3	6 34 11,1	RES = -,36 SEC
S06	ES	6 34 18,3	6 34 18,0	RES = ,76 SEC
S08	ES	6 34 14,5	6 34 13,9	RES = ,68 SEC
S05	EP	6 34 13,9	6 34 13,9	RES = -,26 SEC
S05	ES	6 34 22,3	6 34 21,8	RES = ,37 SEC
S03	ES	6 34 21,4	6 34 20,6	RES = ,01 SEC
ASC	IPG	6 34 4,5	6 34 4,5	RES = -,78 SEC
ASC	IS	6 34 6,0	6 34 6,0	RES = -,58 SEC
ASD	IPG	6 34 5,6	6 34 5,6	RES = -,71 SEC
ASB	IPG	6 34 4,6	6 34 4,7	RES = -1,32 SEC

OCT 4, 1969
H = 6 48 53,3
LATITUDE = 51,440 N
LONGITUDE = 179,249 E
DEPTH = 4 KM
NUMBER OF PHASES USED = 7 STANDARD DEVIATION = ,24 SEC

		CORR, TIME	RAW TIME		
S08	EP	6 48 58,4	6 48 58,6	RES =	,01 SEC
S06	ES	6 49 7,2	6 49 6,9	RES =	-,00 SEC
S05	ES	6 49 12,7	6 49 12,2	RES =	-,00 SEC
ASC	IPG	6 48 54,8	6 48 54,8	RES =	-,18 SEC
ASC	IS	6 48 56,4	6 48 56,4	RES =	,07 SEC
ASD	IPG	6 48 55,8	6 48 55,8	RES =	,51 SEC
ASB	IPG	6 48 55,0	6 48 55,1	RES =	-,30 SEC

OCT 4, 1969
H = 7 31 36,8
LATITUDE = 51,441 N
LONGITUDE = 179,166 E
DEPTH = 7 KM
NUMBER OF PHASES USED = 9 STANDARD DEVIATION = ,72 SEC

		CORR, TIME	RAW TIME		
S06	EP	7 31 44,6	7 31 44,4	RES =	-,18 SEC
S08	EP	7 31 43,7	7 31 43,9	RES =	,52 SEC
S06	ES	7 31 50,9	7 31 50,6	RES =	,36 SEC
S05	EP	7 31 46,4	7 31 46,4	RES =	-,67 SEC
S05	ES	7 31 55,7	7 31 55,2	RES =	1,13 SEC
ASC	IPG	7 31 38,2	7 31 38,2	RES =	-,34 SEC
ASC	IS	7 31 39,6	7 31 39,6	RES =	-,22 SEC
ASB	IPG	7 31 38,2	7 31 38,3	RES =	-1,30 SEC
ASD	IPG	7 31 39,2	7 31 39,2	RES =	-,83 SEC

OCT 3, 1969
H = 20 8 50,2
LATITUDE = 51,405 N
LONGITUDE = 179,252 E
DEPTH = 7 KM
NUMBER OF PHASES USED = 9 STANDARD DEVIATION = ,77 SEC

		CORR, TIME	RAW TIME	
SO6	EP	20 8 59,2	20 8 59,0	RES = ,11 SEC
SO6	ES	20 9 5,4	20 9 5,1	RES = -,17 SEC
SO5	EP	20 9 ,9	20 9 ,9	RES = -,34 SEC
SO5	ES	20 9 9,6	20 9 9,1	RES = ,26 SEC
ASC	IPG	20 8 51,7	20 8 51,7	RES = -1,03 SEC
ASC	IS	20 8 53,2	20 8 53,2	RES = -1,45 SEC
ASD	IPG	20 8 52,8	20 8 52,8	RES = ,52 SEC
ASD	IS	20 8 55,0	20 8 55,0	RES = 1,21 SEC
ASB	IPG	20 8 51,7	20 8 51,8	RES = -,41 SEC

OCT 4, 1969
H = 6 34 3,6
LATITUDE = 51,435 N
LONGITUDE = 179,199 E
DEPTH = 6 KM
NUMBER OF PHASES USED = 10 STANDARD DEVIATION = ,68 SEC

		CORR, TIME	RAW TIME	
SO6	EP	6 34 11,3	6 34 11,1	RES = -,36 SEC
SO6	ES	6 34 18,3	6 34 18,0	RES = ,76 SEC
SO8	ES	6 34 14,5	6 34 13,9	RES = ,68 SEC
SO5	EP	6 34 13,9	6 34 13,9	RES = -,26 SEC
SO5	ES	6 34 22,3	6 34 21,8	RES = ,37 SEC
SO3	ES	6 34 21,4	6 34 20,6	RES = ,01 SEC
ASC	IPG	6 34 4,5	6 34 4,5	RES = -,78 SEC
ASC	IS	6 34 6,0	6 34 6,0	RES = -,58 SEC
ASD	IPG	6 34 5,6	6 34 5,6	RES = -,71 SEC
ASB	IPG	6 34 4,6	6 34 4,7	RES = -1,32 SEC

Table II-14 (Contd)

OCT 4, 1969
H = 6 48 53.3
LATITUDE = 51.440 N
LONGITUDE = 179.249 E
DEPTH = 4 KM
NUMBER OF PHASES USED = 7 STANDARD DEVIATION = .24 SEC

		CORR. TIME	RAW TIME		
S08	EP	6 48 58.4	6 48 58.6	RES =	.01 SEC
S06	ES	6 49 7.2	6 49 6.9	RES =	-.00 SEC
S05	ES	6 49 12.7	6 49 12.2	RES =	-.00 SEC
ASC	IPG	6 48 54.8	6 48 54.8	RES =	-.18 SEC
ASC	IS	6 48 56.4	6 48 56.4	RES =	.07 SEC
ASD	IPG	6 48 55.8	6 48 55.8	RES =	.51 SEC
ASB	IPG	6 48 55.0	6 48 55.1	RES =	-.30 SEC

OCT 4, 1969
H = 7 31 36.8
LATITUDE = 51.441 N
LONGITUDE = 179.166 E
DEPTH = 7 KM
NUMBER OF PHASES USED = 9 STANDARD DEVIATION = .72 SEC

		CORR. TIME	RAW TIME		
S06	EP	7 31 44.6	7 31 44.4	RES =	-.18 SEC
S08	EP	7 31 43.7	7 31 43.9	RES =	.52 SEC
S06	ES	7 31 50.9	7 31 50.6	RES =	.36 SEC
S05	EP	7 31 46.4	7 31 46.4	RES =	-.67 SEC
S05	ES	7 31 55.7	7 31 55.2	RES =	1.13 SEC
ASC	IPG	7 31 38.2	7 31 38.2	RES =	-.34 SEC
ASC	IS	7 31 39.6	7 31 39.6	RES =	-.22 SEC
ASB	IPG	7 31 38.2	7 31 38.3	RES =	-1.30 SEC
ASD	IPG	7 31 39.2	7 31 39.2	RES =	-.83 SEC

Table II-14 (Contd)

OCT 4, 1969
H = 8 43 20,6
LATITUDE = 51,441 N
LONGITUDE = 179,239 E
DEPTH = 4 KM
NUMBER OF PHASES USED = 6 STANDARD DEVIATION = ,25 SEC

		CORR, TIME	RAW TIME		
S05	EP	8 43 31,7	8 43 31,7	RES =	-,07 SEC
S05	ES	8 43 39,9	8 43 39,4	RES =	-,04 SEC
ASC	IPG	8 43 22,1	8 43 22,1	RES =	-,26 SEC
ASC	IS	8 43 23,7	8 43 23,7	RES =	,02 SEC
ASD	IPG	8 43 23,2	8 43 23,2	RES =	,31 SEC
ASB	IPG	8 43 22,4	8 43 22,5	RES =	-,44 SEC

OCT 4, 1969
H = 9 6 24,9
LATITUDE = 51,408 N
LONGITUDE = 179,179 E
DEPTH = 7 KM
NUMBER OF PHASES USED = 8 STANDARD DEVIATION = ,37 SEC

		CORR, TIME	RAW TIME		
S08	IP	9 6 30,9	9 6 31,1	RES =	-,08 SEC
S06	EP	9 6 33,4	9 6 33,2	RES =	-,16 SEC
S06	ES	9 6 40,6	9 6 40,3	RES =	,78 SEC
S05	*EP	9 6 35,3	9 6 35,3	RES =	,13 SEC
ASC	IPG	9 6 26,5	9 6 26,5	RES =	-,43 SEC
ANA	IPG	9 6 33,3	9 6 33,3	RES =	-,47 SEC
ASD	IPG	9 6 27,7	9 6 27,7	RES =	-,10 SEC
ASB	IPG	9 6 26,9	9 6 27,0	RES =	-,19 SEC

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SECTION III

FIELD OPERATIONS

3.1 EXPERIMENT PREPARATION

3.1.1 OCEAN-BOTTOM SEISMOGRAPHS. Fourteen OBS units were removed from storage and prepared for the field experiment. (The remaining two units, OBS 20 and 24, which had been loaned to Lamont-Doherty Geological Observatory could not be repaired in time to meet the contract schedule.) Ten units were scheduled for field deployment, with the other units serving as backup systems and spares.

The most immediate concern was the condition of the Yardney SILVER-CEL® batteries; most of the batteries on hand were those used during the 1967 Aleutian Islands Experiment, and their storage period far exceeded the manufacturer's specified wet life of 9 to 12 months. Load tests run on random samples from each type of battery showed actual cell capacity to be less than 50 percent of rated capacity. Fourteen sets of new batteries were ordered and expedited to meet the field operations schedule. Amp-hour capacity of the old batteries was sufficient for the OBS system checkout in Dallas.

System checkout primarily involved general instrument cleaning, replacement of dry cells in the calibration and backup-clock units, and replacement of O-rings. Units which required other than routine maintenance were

- Unit 15 (repaired E-W and Z seismometer inputs to amplifiers; replaced pressure switch)
- Unit 16 (repaired 12-v regulator)
- Unit 18 (replaced current-limiting resistor on regulator board)
- Unit 19 (replaced pressure switch)
- Unit 21 (repaired sonar amplifier; replaced hydrophone and male antenna jack)

In addition to system testing and maintenance, two modifications of the OBS units were made.

The first modification, which involved only the Mark-IV units, was insertion of an R-C series network across the input terminals of each unity-gain operational amplifier in the trilevel amplifier channels (Figure III-1). Addition of these components eliminated the tendency of the amplifier to oscillate when used in the unity-gain configuration. Modification was not required on the Mark-V units due to internal changes in the operational amplifiers.

The second modification was performed on all units and consisted of placing a 68-kilohm resistor across pins B and H of J104 and running a lead from pin H of J104 to terminal 3 of TS1002 (Figure III-2). This modification makes the digital-clock time-code output available at the external release wire so that digital-clock operation can be monitored after the sphere has been closed. It has the additional advantage of providing a means whereby the digital-clock output can be recorded on an oscillograph and compared with WWV and/or a secondary time standard immediately prior to launch and immediately after recovery. This comparison permits calculation of clock drift essentially over the period that the unit was actually in the water. Previously, it was necessary to close the sphere as late as possible before launch and open it as quickly as possible after recovery to obtain this time check. A further advantage is that, if rough seas make at-sea prelaunch checkout hazardous, it is now possible to completely prepare the units for launch before leaving port.

3.1.2 AUXILIARY EQUIPMENT. Preparation of the auxiliary equipment primarily involved cleanup and testing, calibration of measurement instrumentation, routine maintenance, and replenishment of the spares complement. Due to an excessive drift-rate problem, the rubidium frequency standard used with the Omega/VLF navigation system was returned to the factory for repair.

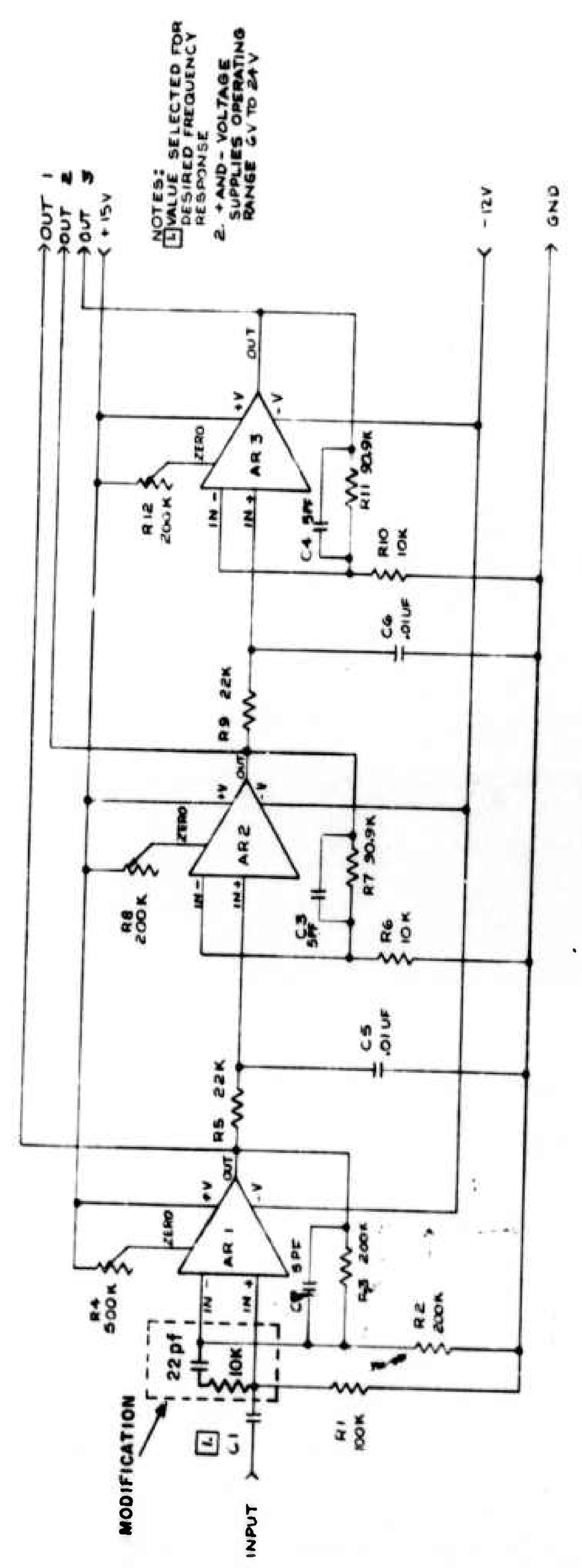

Figure III-1. Modification to Mark-IV Trilevel Amplifiers

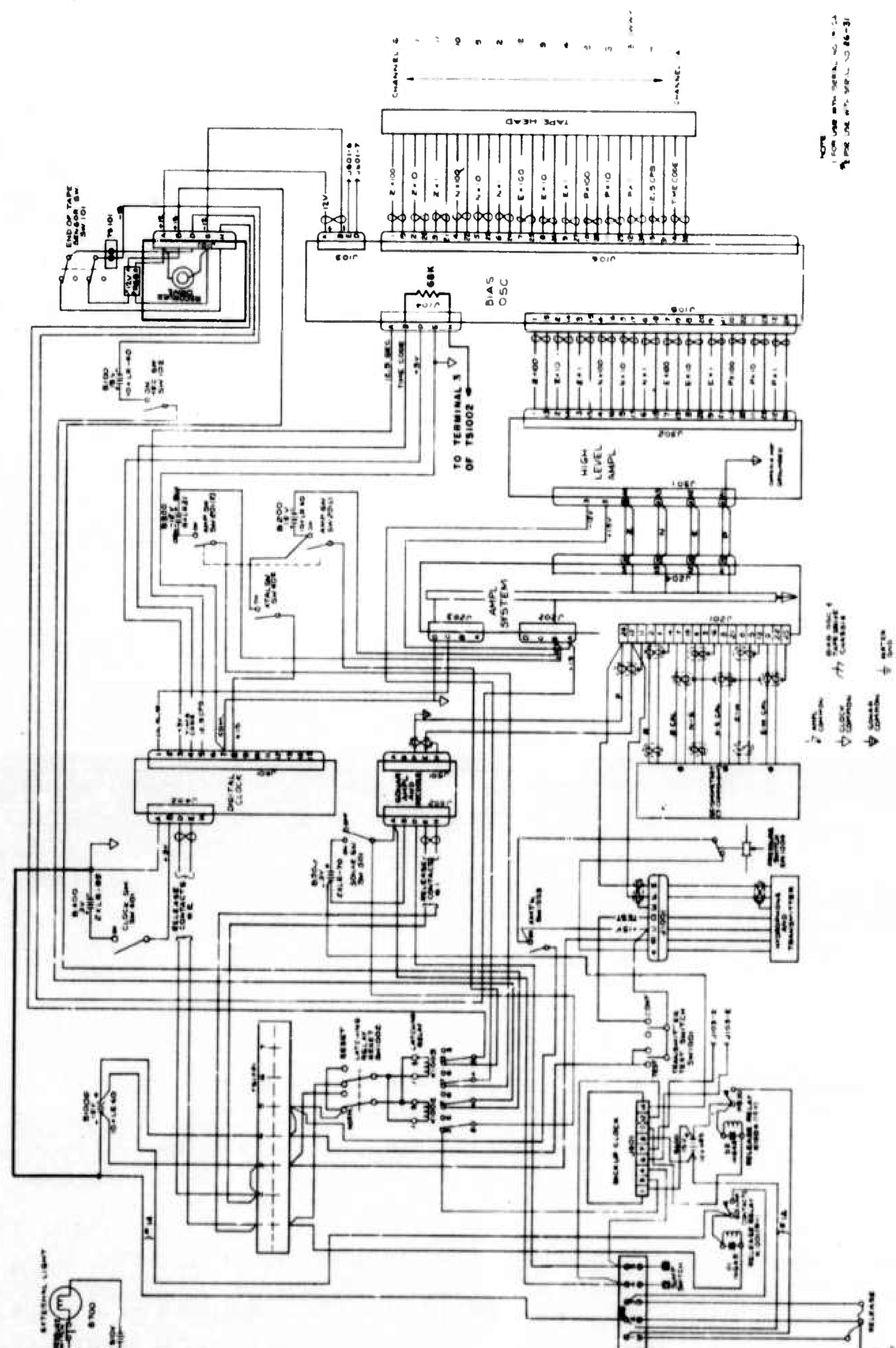

Figure III-2. Modification to OBS System

Major items of auxiliary equipment purchased were

- Systron-Donner Model 8150-306 time-code generator with slow code option A
- RF Communications SSB transceiver, Type SB6FB with 1-kw linear amplifier, Type RF 102 (lease-purchase agreement from 29 August to 28 November; purchased 2 December)
- Nobrush Model 30-003 400-cycle converter (used with GSI-owned Sperry Loran-C receiver)
- 30 base-anchor castings

Purchase of the time-code generator provided an accurate and reliable secondary time standard which can be easily traced to WWV. The generator contains a crystal-controlled oscillator accurate to 1 part in 10^7 per day, and provisions are included for the use of an external 1-MHz time base. Generator output is a binary seconds-minutes-hours code with a 30-sec time frame.

3.1.3 SHIP SELECTION. Due to the time factor, only vessels available on the West Coast were surveyed for use during the MILROW experiment. The M/V SEA SCOPE (Figure III-3) was selected as being the most suitable, based on ease of rigging, rigging costs, speed, and accommodations.

Built in 1945, the SEA SCOPE is a U.S. Coast Guard-certified vessel and was used in a previous OBS operation in the Kurile Islands and Aleutian Islands areas. Specifications of this vessel, which is owned by the Sea Scope Corporation of Santa Barbara, California, are given on the following page.

Length	185 ft 2 in.
Beam	33 ft
Draft	9 ft 6-3/4 in.
Tonnage	
Gross	685
Net	522
Propulsion	Twin screw, two 1800-hp Alco diesels
Range	10,000 mi
Endurance	30 days
Speed	
Cruising	12 knots
Maximum	14 knots
Crew complement	17
Scientific staff	13
Power	One 100-kw, 60-Hz, 220-v supply Two 60-kw, 60-Hz, 220-v supplies
Radar	Decca Model 404
Gyro	Sperry Mark IV
Radio	Northern 23-channel unit

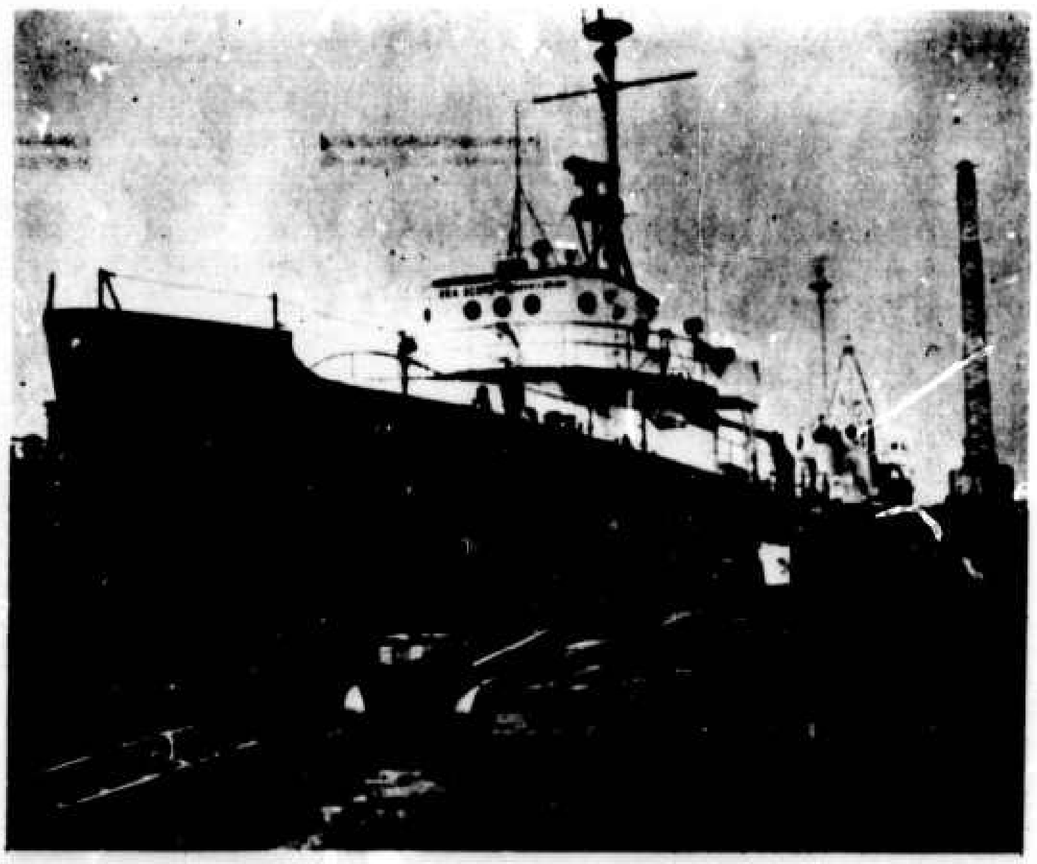

Figure III-3. M/V SEA SCOPE

3.1.4 SHIP RIGGING. The SEA SCOPE was placed in drydock at Fellows and Stewart Shipyard, Terminal Island, California, from 25 to 28 August 1969. During this period, the bottom was cleaned and painted, the Edo 12-kHz transducer for the fathometer was installed, and vessel recertification was obtained.

Ship rigging was performed at Stearns Wharf, Santa Barbara, California, from 29 August to 5 September. Four lengths of 4-in. channel were welded along the length of the cargo hold to serve as tracks for moving and securing the OBS units. Additional channel was welded thwart ship at the forward end of the hold so that the units could be sidetracked for testing and checkout. A small winch was installed at the forward end of the hold to aid in moving the units.

Two work benches were installed in the cargo hold, and a third was installed in the sonar-recall room. Padeyes were welded to the deck on the starboard side of the cargo hatch so that two OBS units could be secured on deck. Additional padeyes were welded to the 0-1 deck to secure the spare anchors.

A Galeon Model 125 hydraulic crane (12-1/2-ton capacity) was welded aft of the cargo hatch on the vessel centerline. Placement of the crane in this location provided easy access to the cargo hold and also permitted the units to be launched and/or recovered from either side of the vessel.

The antenna complement installed aboard the SEA SCOPE consisted of

- 35-ft whip — single-sideband (SSB) communications
- 30-ft whip — Loran-A/C receivers
- 25-ft whip — Omega/VLF receivers
- 9-ft whip — OBS beacon receiver
- 9-ft whip — general receiver, WWV
- ADF loop — direction finder

A field engineer from Meva Electronics, Seattle, Washington, was engaged to install and align the Sperry Loran-C receiver. The results of this effort were disappointing primarily because of the receiver's dependence on a stable 400-Hz input power source. Frequency variations in the ship's power, which was converted from 60 Hz to 400 Hz, exceeded the tolerances required for proper receiver operation.

Major equipment items installed aboard the SEA SCOPE are listed below according to location.

- Navigation room
  - Omega/VLF navigation system
  - Sperry Loran-C receiver
  - D-X Navigator Loran-A/C receiver
  - Bendix ADF receiver
  - Cadre 510-A receiver
  - Hammarlund receiver
  - time-code generator
  - Ocean Sonics GDR-T precision depth recorder
  - 1-kw linear amplifier (for SSB transceiver)
- Cargo hold
  - OBS units
  - Cadre 510-A receiver
  - battery chargers
  - test equipment
- Sonar-recall room
  - sonar-recall cabinet
  - Honeywell Visicorder and galvo amplifiers
  - WWVT receiver
- Radio room
  - RF Communications SB6FB SSB transceiver

An intercom system connecting the bridge, navigation room, galley, and cargo hold was established. Miscellaneous items such as floodlights, electrical outlets, etc., were installed as required.

3.1.5 SHAKEDOWN CRUISE. A shakedown cruise was conducted off Santa Barbara from 6 to 8 September 1969. The purposes of this cruise were to test the six OBS units assembled in 1968 which had not been tested operationally, check out auxiliary equipment and ship's rigging, and orient new TI personnel and ship's crew to OBS procedures. Each unit was launched with a buoy line attached to the anchor to permit retrieval after the unit was recalled.

Five units were launched and, after approximately 24 hr on the bottom, were recovered by sonar recall. The sixth unit, OBS 30, was dragged along the bottom for a short time after launch when the buoy line became entangled in the ship's rudder. This unit surfaced 2 hr later and was recovered by a crew boat which had been employed to stand by in the area. Damage to the unit was minor. Tapes from these units were returned to Dallas and examined for proper unit operation.

The amount of at-sea time logged during these tests was substantially below plan due to heavy fog throughout the morning hours. This factor, along with the requirement for the vessel to return to port each evening for completion of rigging operations, reduced the time available to test the operation of all auxiliary equipment; therefore, testing of the ADF and timing equipment was not accomplished. Performance of all equipment tested was satisfactory with the exception of the Sperry Loran-C receiver; frequency variations of ship's power resulted in very sporadic operation.

Final rigging operations were completed on 9-10 September, and the SEA SCOPE sailed for Amchitka at 1800Z on 10 September.

3.2 AT-SEA OPERATIONS

The SEA SCOPE arrived at Amchitka on 23 September 1969; heavy seas encountered while enroute to the island delayed the arrival by approximately 3 days. Texas Instruments technical personnel had arrived in advance of the vessel to insure proper coordination of communication and logistic-support requirements with the AEC. Prelaunch preparations were completed on 23-24 September.

3.2.1 OCEAN-BOTTOM SEISMOGRAPH PROGRAM. Ten OBS units were deployed around Amchitka Island in the pattern illustrated in Figure III-4. Deployment operations were conducted on 25, 26, 27, and 30 September under very favorable weather conditions. The only equipment difficulty encountered was a hydrophone malfunction on unit 18 which was detected during prelaunch checkout; this unit was replaced by unit 25. Digital-clock and backup-clock programmed releases were set at 30 days and 31 days, respectively. Unit drop information is summarized in Table III-1, with stations listed according to launch sequence.

Use of the time-code generator as a secondary time standard produced good results. The rubidium frequency standard was used as an external time base for the generator to reduce drift to a minimum. After prelaunch checkout, the output of the time-code generator was applied to the pressure-channel input, and approximately 5 min of time-code information was recorded before closing the sphere. Reset of the digital clock was accomplished during this 5-min interval, and a comparison of the reset pulse with the time code during analysis permitted the exact clock reset time to be established.

Immediately prior to launch and immediately after recovery, the time-code generator output, WWV signal, and OBS digital-clock output were recorded simultaneously on the oscillograph. These signals were compared to provide a positive check on timing accuracy. This procedure was not instituted until after the first four units had been deployed; time checks were made before each of the remaining six launches and after each recovery.

The SEA SCOPE sailed from Amchitka on 1 October to stand by at coordinates 51°31.0'N, 178°12.8'E. MILROW was detonated at 2206Z on 2 October, and the vessel received clearance to return to the island 1 hr later.

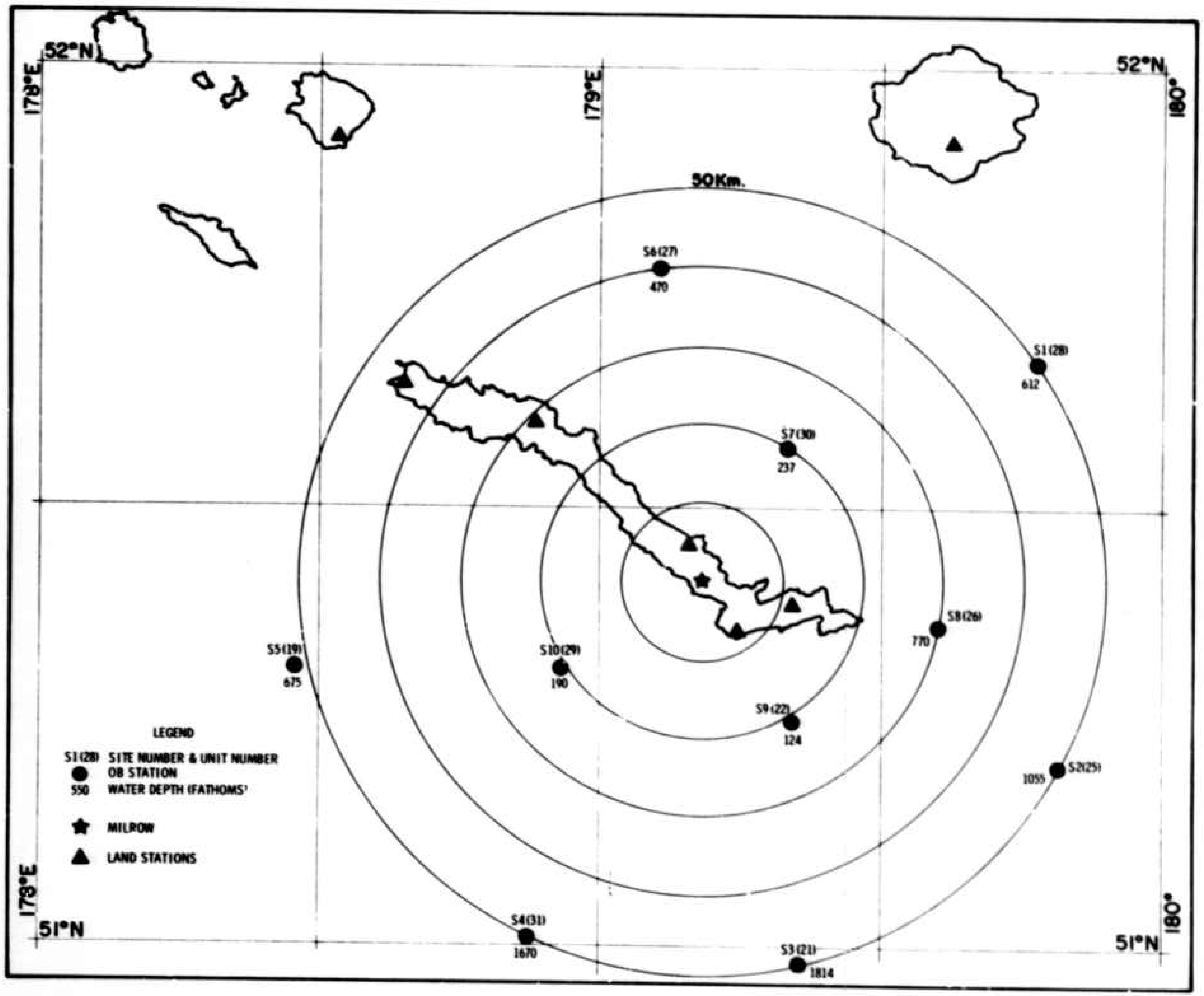

Figure III-4. OBS Deployment Pattern

Table III-1

OBS DEPLOYMENT SUMMARY

Station	OBS Unit	Deployment Date	Water Depth (fm)	Latitude	Longitude	Digital-Clock Reset**
7	30	9/25	237	51°34.0'N*	179°20.0'E	9/25 0740Z
6	27	9/26	470	51°46.5'N*	179°06.5'E	9/25 0828Z
1	28	9/26	612	51°40.0'N	179°47.0'E	9/25 2115Z
8	26	9/26	770	51°22.0'N*	179°35.7'E	9/25 2242Z
9	22	9/27	124	51°15.5'N	179°20.7'E	9/26 0804Z
10	29	9/27	190	51°19.0'N	178°55.8'E	9/26 0751Z
5	19	9/27	675	51°19.0'N*	178°27.5'E	9/27 0500Z
4	31	9/30	1670	51°00.5'N	178°52.3'E	9/29 2055Z
3	21	9/30	1814	50°59.0'N*	179°21.5'E	9/29 2007Z
2	25	9/30	1055	51°12.5'N	179°48.5'E	9/29 2345Z

*Indicates deployment coordinates after final analysis of navigation data. This analysis was performed only for those stations from which raw data were obtained. Remaining coordinates are approximate deployment locations.

**Indicates digital-clock reset times obtained from field data. Exact time of reset is determined during data analysis.

Checkout and calibration of the ADF equipment was performed on 14 October. An OBS unit was placed on the dock with the beacon transmitter in operation while the SEA SCOPE maneuvered in the harbor. All equipment functioned satisfactorily.

Table III-2

OBS RECOVERY SUMMARY

Station	OBS Unit	Recall Method	Component Operation: Transmitter	Component Operation: Beacon Light	Remarks
8	26	Sonar	Yes	No	——
2	25	Backup clock	Yes	Yes	Unit recovered by SEA SCOPE while enroute to Santa Barbara
3	21	Sonar	Yes	No	——
4	31	——	——	——	Unit not recovered
5	19	Sonar	Yes	No	Beacon light intermittent when sighted; failed before recovery
10	29	Sonar	Yes	Yes	Unit released during sonar recall of station 4 or station 5
9	22	Sonar	Yes	No	Time code not taped after recovery due to recorder malfunction
1	28	——	——	——	Unit not recovered
6	27	Sonar	Yes	Yes	——
7	30	Sonar	Yes	Yes	Postrecovery time check not made until sphere was opened

Prime recovery operations were conducted from 16 to 18 October, and seven units were recovered by sonar recall. OBS recovery operations are summarized in order of sonar recall in Table III-2. A minimum of 6 hr per station was spent attempting to recall the remaining three units. Subsequent searches of the areas of these three stations on 25, 26, and 30 October for possible clock recall were conducted without success.

The SEA SCOPE departed for Santa Barbara on 1 November 1969. Approximately 4 hr after departure, the beacon light on unit 25 (station 2) was sighted. Unit retrieval was accomplished by members of the ship's crew, and the vessel returned to Amchitka for removal of the tape reel. The SEA SCOPE then resumed her transit to Santa Barbara.

Weather conditions were very favorable throughout the conduct of OBS operations. Although several storm systems passed through the Amchitka area during the field-operations period, the launch and recovery schedule was not affected.

3.2.1.1 Navigation. Overall navigation accuracy during the MILROW experiment was considered good. The major disappointment was performance of the Sperry Loran-C which proved to be useless due to very sporadic operation. The primary difficulty was the frequency instability of ship's power, but poor signal strength was also a contributing factor.

Due to the proximity to Amchitka, it was not necessary to employ celestial or dead-reckoning navigation. The methods of navigation used were Omega, Loran A, and radar; the effectiveness of each of these methods is discussed in the following paragraphs. Table III-3 shows the estimated navigation accuracy of the launch/recovery coordinates for each station.

Table III-3

ESTIMATED ACCURACY OF
OBS STATION LOCATIONS

Station	Launch Coordinates		Recovery Coordinates		Estimated Accuracy (mi)
	Latitude	Longitude	Latitude	Longitude	
1	51°40.0'N	179°47.0'E	Not recovered		±0.5**
2	51°12.5'N	179°48.5'E	Not available*		±1.5**
3	50°59.0'N	179°21.5'E	51°00.0'N	179°19.1'E	±1.0
4	51°00.5'N	178°52.3'E	Not recovered		±2.0**
5	51°19.0'N	178°27.5'E	51°19.3'N	178°25.3'E	±1.0
6	51°46.5'N	179°06.5'E	51°47.0'N	179°05.6'E	±0.5
7	51°34.0'N	179°20.0'E	51°33.4'N	179°15.8'E	±0.5
8	51°22.0'N	179°35.7'E	51°20.7'N	179°33.2'E	±0.5
9	51°15.5'N	179°20.7'E	51°15.5'N	179°19.9'E	±0.5**
10	51°19.0'N	178°55.8'E	51°17.6'N	179°00.3'E	±0.5**

*SEA SCOPE recovered unit from station 2 while enroute to Santa Barbara.

**Accuracy estimation based only on preliminary field investigation of data, final analysis was not performed, since no raw data were obtained from these stations.

3.2.1.1.1 Omega. Charts covering the area of operations were obtained for the following stations:

- ALDRA (13.6 kHz) — Omega station in Norway
- HAIKU (13.6 kHz) — Omega station in Hawaii
- TRINIDAD (13.6 kHz) — Omega station in Trinidad
- GBR (16.0 kHz) — VLF station in England
- NSS (21.4 kHz) — VLF station in Maryland
- NPG (18.6 kHz) — VLF station in the state of Washington

Reception from TRINIDAD and NSS was very poor, and NPG was off the air for modification during the operations period. GBR reception was too poor at the beginning of the program to obtain sufficient diurnal information. Therefore, ALDRA and HAIKU were used to obtain Omega positions.

Diurnal corrections for ALDRA and HAIKU were obtained before and after both the launch and recovery operations. These curves are presented in Figure III-5 through Figure III-8.

The quality of reception from ALDRA and HAIKU was acceptable throughout the launch and recovery operations. Neither station was off the air at any time during these periods, and variations in the daily diurnal curves were not considered excessive. When plotting the final Omega positions for launch and recovery, an average value of the diurnal-shift curves for the appropriate period was used.

3.2.1.1.2 Loran A. Since the operations area was approximately midway between the Loran-A stations at Shemya and Adak, Loran A (rate 1L2) proved to be a very reliable and useful navigation aid for determining position longitude. Loran-A lines of position were checked frequently during the in-port periods and also compared at sea with positions determined by other methods. This aid was extremely useful during the sonar-recall phase and when search operations were being conducted.

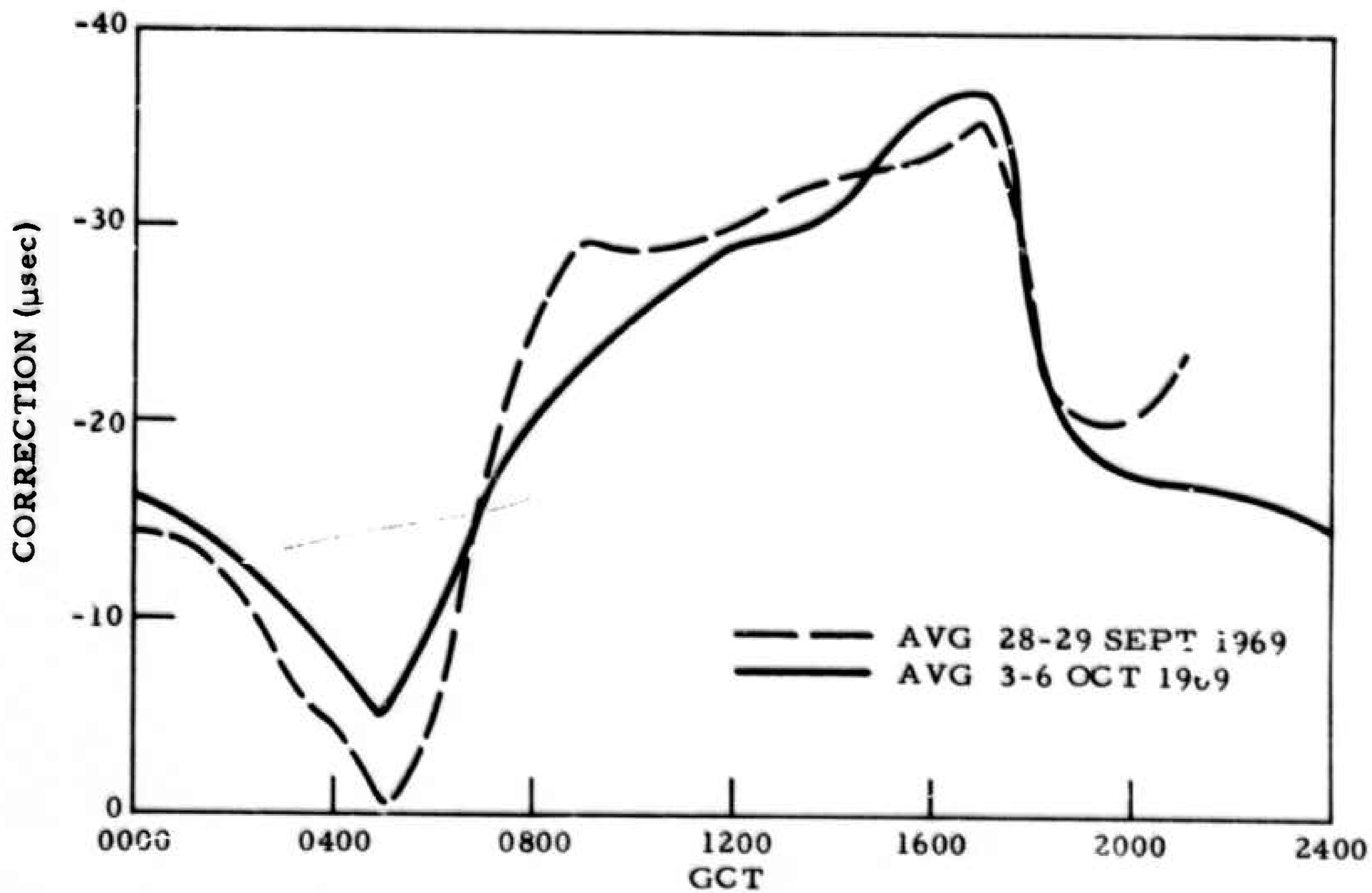

Figure III-5. ALDRA Diurnal Corrections, Amchitka, Alaska, 28-29 September and 3-6 October 1969

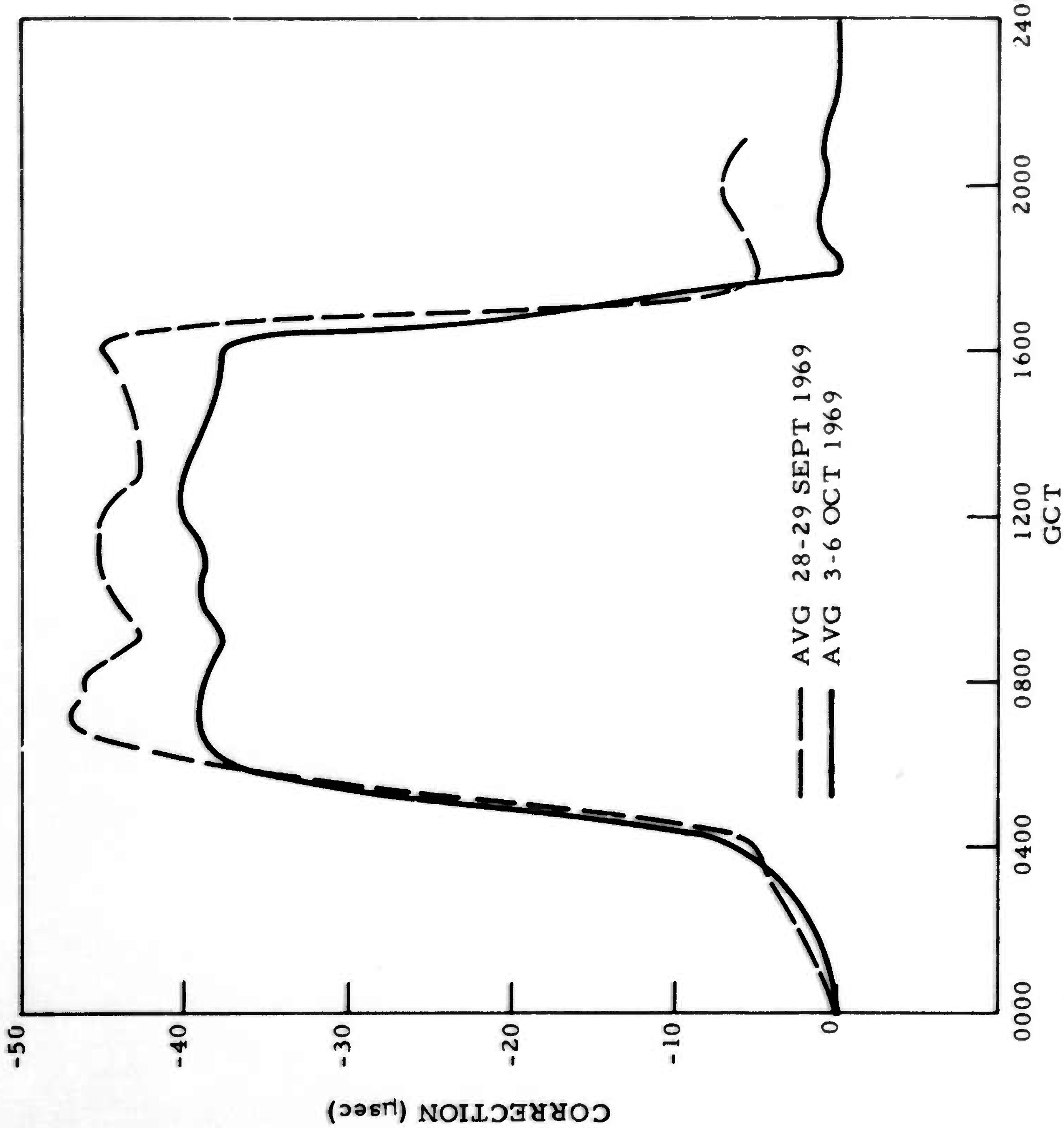

Figure III-6. HAIKU Diurnal Corrections, Amchitka, Alaska, 28-29 September and 3-6 October 1969

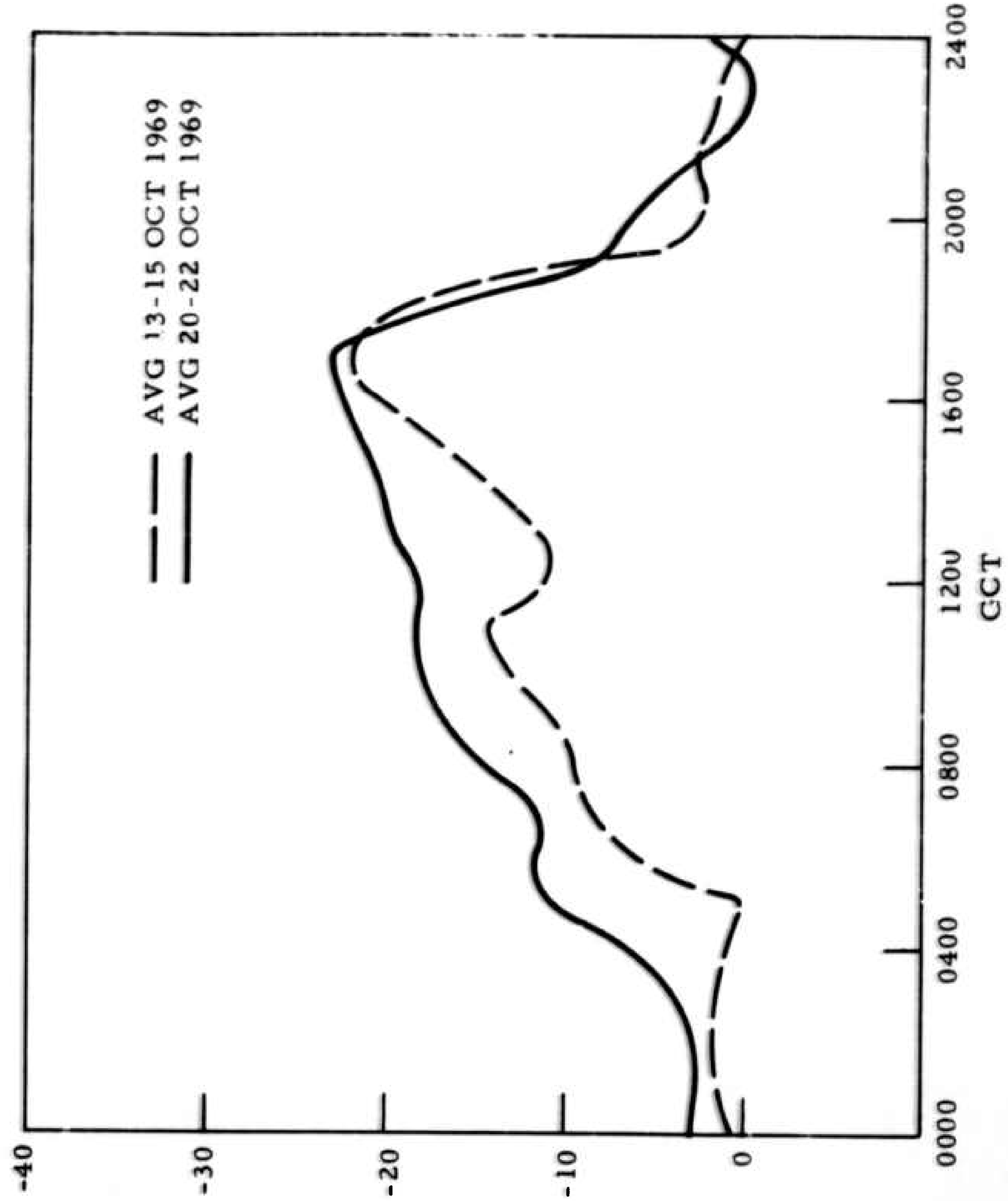

Figure III-7. ALDRA Diurnal Corrections, Amchitka, Alaska, 13-15 October and 20-22 October 1969

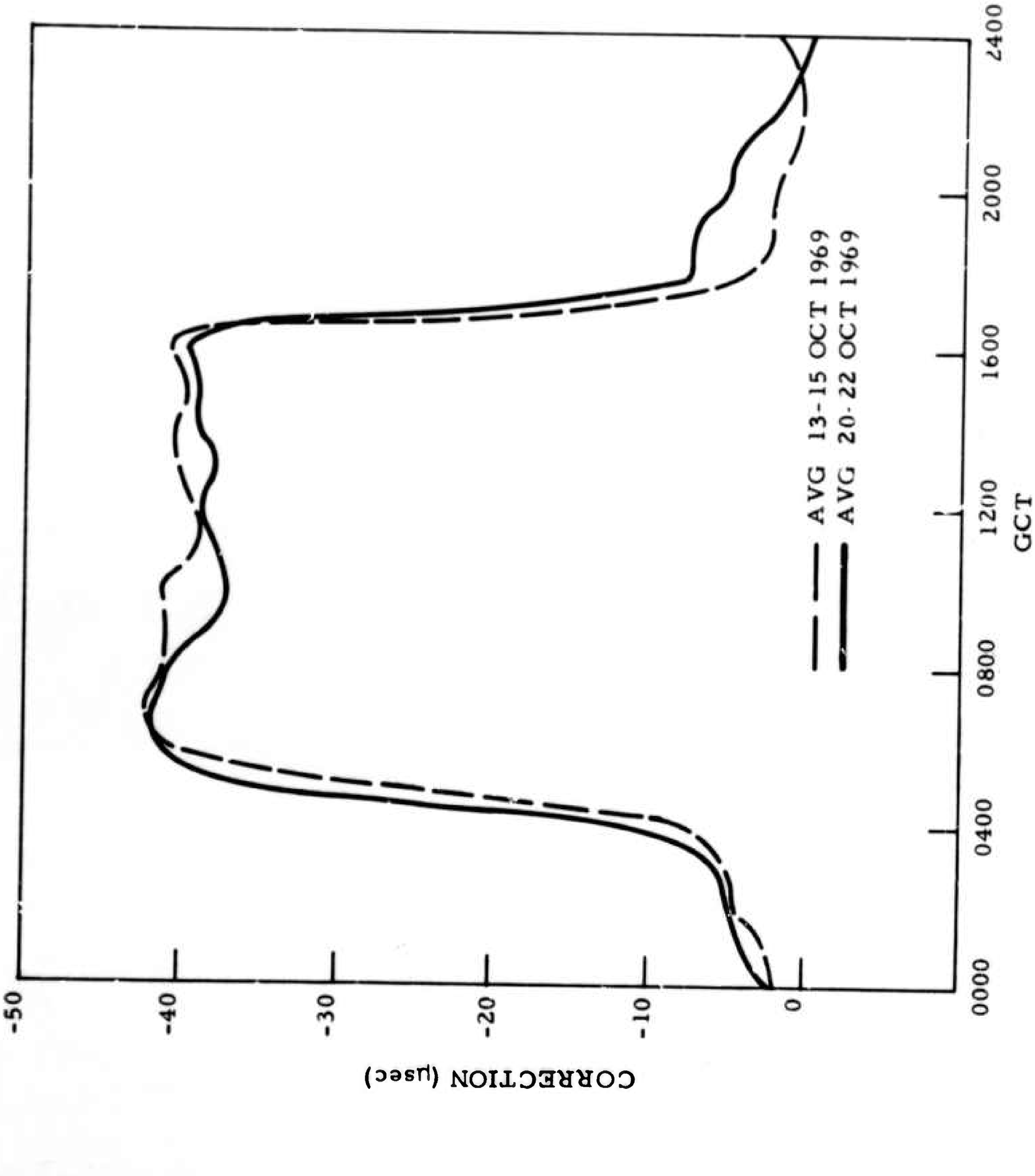

Figure III-8. HAIKU Diurnal Corrections, Amchitka, Alaska, 13-15 October and 20-22 October 1969

3.2.1.1.3 Radar. The Decca Model 404 radar unit aboard the SEA SCOPE was the primary navigation aid utilized on those stations located on the 20- and 30-km rings. It was also used successfully on stations 1 and 6, where it was possible to obtain bearings from Semisopochnoi Island.

3.2.1.2 Communications. Texas Instruments maintains a radio station in Dallas (call letters KUK) to maintain contact with its various marine operations. During the MILROW experiment, the SEA SCOPE was assigned the call letters WX5102, unit 7. A 24-hr operating schedule was established. The single-sideband transceiver aboard the SEA SCOPE was equipped to operate at the following frequencies:

Frequency (kHz)	Station
4133.0	KOV (AEC-Amchitka)
6200.5	KUK (TI-Dallas)
7610.0	MARS (NAVCOM-Adak)
8273.0	KTE-97 (TI-Anchorage) KOV (AEC-Amchitka) KUK (TI-Dallas)
12410.5	KUK (TI-Dallas)
16537.0	KUK (TI-Dallas)

Single-sideband communications with Dallas were extremely dependent on time of day. In general, traffic was very good between 0300Z and 1000Z, and daily contacts could be made. At other times ommunications were unreliable.

The AEC long-line system was also available for stateside communications and operated 24-hr per day. Poor clarity of reception, however, occasionally prevented transmission of field data.

Local communications (i. e., ship-to-ship and ship-to-shore) were much more reliable. The AEC supplied two portable transceivers which operated on the Amchitka Net-A frequency. These units were very useful for communications between the dock area and main camp and, in certain instances, for ship-to-shore communications. The SSB transceiver and Northern marine radio aboard the SEA SCOPE provided all additional coverage required.

3.2.1.5 Logistics and Support. Logistical support requirements on Amchitka were coordinated by the TI operations assistant and/or the AFTAC technical monitor. Cooperation of the AEC site manager and other Amchitka-based AEC personnel was excellent. Requests for control-tower monitoring of the OBS beacon transmitter frequency, as well as requests for fuel and commissary items, received prompt attention. Aid in obtaining flights over the OBS deployment area to monitor for premature surfacing of the units was also furnished.

3.2.2 BATHYMETRIC SURVEY. A post-MILROW bathymetric survey of the southern offshore Amchitka area was conducted from 8 to 10 October 1969. Survey tracks, supplied by the USGS, were identical to those surveyed by the R/V THOMAS G. THOMPSON shortly before the MILROW event. This experiment was performed to detect any evidence of sediment slumping which could be attributed to the explosion.

Survey equipment consisted of an Ocean Sonics GDR-T precision depth recorder and an Edo 12-kHz transducer. Several tracks were surveyed more than once to improve on record quality and/or navigation accuracy. Omega, Loran A, and radar were employed as navigation aids, with radar proving to be most useful. Diurnal variations for Omega ALDRA and Omega HAIKU were plotted for the 2-day periods before and after the survey, but the day-to-day variations of the ALDRA diurnals were sufficiently large to make the usefulness of ALDRA data questionable. Additionally, HAIKU was off the air from 1904Z on 9 October to 0230Z on 10 October.

Table III-4

END-POINT COORDINATES OF BATHYMETRIC SURVEY TRACKS

Point	Latitude	Longitude
0 (start)	51°11.1'N	179°16.4'E
1	51°23.0'N	179°08.5'E
2	51°24.2'N	179°04.2'E
2*	51°24.3'N	179°04.6'E
3	51°18.6'N	179°08.0'E
4	51°10.8'N	179°10.2'E
5	51°10.3'N	179°10.0'E
6	51°13.2'N	179°04.7'E
7	51°18.8'N	179°00.5'E
8	51°28.2'N	178°58.1'E
9	51°31.8'N	178°49.6'E
9A**	51°19.8'N	178°56.8'E
10	51°10.5'N	179°05.0'E
11	51°09.9'N	179°02.5'E
12	51°10.6'N	178°59.9'E
13	51°16.5'N	178°54.5'E
14	51°25.7'N	178°50.7'E
15	51°32.6'N	178°43.1'E
16	51°27.4'N	178°59.0'E
17	51°20.3'N	179°04.2'E
18	51°23.8'N	179°04.9'E
19	51°19.1'N	179°11.8'E
20	51°16.8'N	179°16.6'E
21	51°20.0'N	179°16.8'E
22 (end)	51°16.8'N	179°21.3'E

*Indicates start position for survey of track 2-3.

**Indicates point of course change during survey of track 9-10.

A thorough analysis of all navigation data was performed in Dallas following the survey. The final navigation results represent a combination of radar, Loran A, and Omega data after weighing the information from each source according to signal strength, time of day, and reliability during the survey. Navigation accuracy is estimated at ±1/4 mi within 7 mi of the island and ±3/4 mi for distances beyond 7 mi.

End-point coordinates of the survey tracks are listed in Table III-4. For those tracks which were surveyed more than once, coordinates are listed only for the last survey. Survey data were forwarded to the USGS for analysis.

3.2.3 WATER-SAMPLE SURVEY. At the request of the AEC site manager, the SEA SCOPE was made available to personnel from Isotopes Inc. to conduct a water-sample survey in the nearshore Amchitka area on 23-24 October. Water depth permitting, samples were pumped aboard the vessel. In the shallower depths, a life boat was deployed, and samples were obtained with a bucket.

3.3 FAILURE ANALYSIS AND EQUIPMENT EVALUATION

Of the eight OBS units recovered, five units contained some useful data. However, data quality from two of these units was significantly affected by equipment malfunctions. This section contains a discussion and analysis of the equipment malfunctions and a general evaluation of OBS equipment.

3.3.1 OCEAN-BOTTOM SEISMOGRAPHS. The three units which functioned properly throughout the on-bottom recording period were located on stations 5, 6, and 8 (OBS units 19, 27, and 26, respectively). Each of the remaining units malfunctioned to some degree; the following is a discussion of the malfunctions, the causes (if determinable), and the resultant effect on data collection.

3.3.1.1 Station 1 – Unit 28. This unit was not recovered, although sonar recall was attempted for two 4-hr periods and lengthy search operations were conducted during the programmed clock-release periods. Comparison of bathymetric data recorded during launch with that obtained during recovery attempts and the excellent agreement among the navigation aids verified that the ship was on station. No explanation for the unit's failure to release is available.

3.3.1.2 Station 2 – Unit 25. Unit 25 was recovered by the SEA SCOPE while enroute Santa Barbara after completing the field operations. Attempts at sonar recall and a search of the area at the time of backup-clock release had been unsuccessful. Although an accurate fix was not obtained, the unit was approximately on station at the time of recovery. This factor – and the operation of the tape recorder for the full 30-day period – indicates that the unit was released by the backup clock. (Digital-clock release was not possible for reasons discussed later.) The unit's failure to surface immediately is attributed to entanglement with the anchor of a "tag" line which could not be freed at time of launch.

Inspection of the unit revealed that the main wiring harness had developed a short which extensively damaged a section of the harness. The lead from the B200 supply had burned in two, which removed power from the reactance amplifiers and the digital-clock oscillator. When power is removed from the digital-clock oscillator, the clock free-runs at about 60-percent normal rate. Therefore, digital-clock release would not be activated until approximately 41 days after clock reset. Two integrated circuits in the digital clock were also damaged.

Examination of the tape film showed that the malfunction occurred 49 min after clock reset, evidenced by an abrupt change in the clock rate and loss of signal on the data channels. Due to the severity of the malfunction, the exact cause could not be determined.

Failure of the unit to respond to sonar recall was connected with the malfunction just described. The release contact leads which connect the sonar amplifier and decoder unit to the release relay leads at TS1001 are part of the main wiring harness; the positive lead was open in the damaged section of the harness.

After replacement of the digital clock and the damaged wires in the harness, the unit was thoroughly tested; all components including the sonar-release subsystem functioned properly.

3.3.1.3 Station 3 — Unit 21. The tape-recorder takeup reel in this unit bound against the beacon transmitter, and all of the tape was deposited in the bottom of the sphere. Binding resulted from slight misalignment of the transmitter.

Approximately 73 percent of the raw data recorded by the unit was useful for event-arrival analysis only. The remaining event-arrival data and all amplitude information were not useful for analysis due to tape-speed fluctuations. Poor tension in the tape-recorder pinch-roller springs was found to be the cause of this problem. Proximity of the tape to the seismometer magnets when it was deposited in the bottom pan apparently did not significantly affect the data.

3.3.1.4 Station 4 — Unit 31. This unit was not recovered, and the cause of failure cannot be stated conclusively. However, examination of the prelaunch time-check information showed that the digital clock did not reset to 0 days but rather to 22 days. With proper digital-clock and release-mechanism operation, the unit would have released on 6 October.

If release actually occurred, the beacon transmitter apparently failed to function properly; the Amchitka control tower was periodically monitoring the beacon frequency at this time, and the SEA SCOPE was in the station area on 8 October conducting the bathymetry survey. Normal operating range of the transmitter is sufficient for reception by each of these monitors.

3.3.1.5 Station 7 — Unit 30. None of the raw data obtained by this unit could be used for event-arrival or amplitude analysis due to excessive clock drift and fluctuations in the tape speed. Cause of the tape-speed fluctuations was the same as that described for station 3, unit 21.

Excessive clock drift — roughly 5.5 min — was attributed to the poor stability vs temperature characteristics of the particular clock oscillator and the relatively shallow depth of the station. Most of the clock drift occurred between the times of clock reset and launch when the ambient temperature inside the sphere greatly exceeded the crystal design temperature of 2°C. Also, since the water temperature at the bottom undoubtedly exceeded the usual oscillator operating temperature (4°C) at the deeper stations, a slightly higher clock-drift rate was expected.

3.3.1.6 Station 9 — Unit 22. The tape-recorder drive motor developed a short circuit shortly after launch, and no data were obtained from this unit. All subsystems functioned properly after the motor was replaced. Cause of the malfunction was not discernible.

3.3.1.7 Station 10 — Unit 29. No data were obtained from this unit because the tape-recorder pinch-roller springs were locked in the open position when the sphere was closed. This was simply a human error, and no equipment malfunction occurred.

The digital clock in this unit was losing 1 sec every 42 sec at the time of recovery. This is usually indicative of low voltage input to the oscillator, but postrecovery supply-voltage measurements made aboard ship were within tolerance. Oscillator-drift tests conducted in Dallas during refurbishment showed no further indication of the high drift rate, and the unit is considered ready for field use.

3.3.1.8 Beacon Lights. Four of the beacon lights failed to operate properly after unit release due to flooding of the assembly. Although the percentage of beacon-light malfunctions traditionally has been high, it had not approached this magnitude. The high malfunction percentage during the MILROW operation apparently resulted from using a dry cell of different manufacture than in previous operations. Both manufacturers specify identical physical dimensions, but the batteries used were difficult to insert in the beacon-light assembly. This slight oversize could prevent the O-ring in the pressure-case-assembly end plate from seating properly and permit seawater to enter the case.

3.3.1.9 Digital Clocks. OBS digital-clock drifts are presented in Table III-5. All of the drifts noted — with the exception of station 7 — are within the limits expected from past operations. As discussed previously, the frequency vs temperature characteristics of the oscillator used on station 7 are poor; this oscillator should be replaced before the clock is used again.

Table III-5.

OBS DIGITAL-CLOCK DRIFTS

Station	Unit	Clock	Clock Drift*
3	21	21	0.1 sec
5	19	19	-1.0 sec
6	27	27	0.7 sec
7	30	30	-5 min 38.1 sec
8	26	1	-0.4 sec
9	22	22	-1.0 sec

*Time gained

3.3.1.10 Tape Recorders. Partial or complete loss of data on three stations was a direct result of tape-recorder malfunctions. (Failure to engage the pinch rollers on station 10 was a human error and has not been included.) In two of these cases, the difficulty was traced to poor tension in the pinch-roller springs. Postrecovery unit inspection revealed that spring tension was marginal in several other recorders. All recorders have been tagged for spring replacement prior to any future operation.

3.3.2 AUXILIARY EQUIPMENT. The following paragraphs discuss only those items of auxiliary equipment which malfunctioned during the operation or which represent significant improvements over previous operations. Performance of all other equipment was considered satisfactory.

3.3.2.1 Depth Recorder. A malfunction in this unit was detected after completion of the bathymetric survey. A component on one of the variable-frequency divider boards had failed, which resulted in a depth error of 20 percent on all scales above the 40-fm scale. Although it was impossible to determine the exact time of failure, comparisons of bathymetric charts and data limited the time of occurrence to the interval between the last OBS launch and start of the bathymetric survey.

3.3.2.2 Time-Code Generator. That the time-code generator performed satisfactorily as a secondary time standard has been mentioned previously. The addition of this unit to the OBS equipment complement — together with the modification which makes the digital-clock output available externally — is considered to be a major improvement. It is now possible to monitor the digital-clock output at any time prior to launch and to reference the digital clock to WWV immediately before launch and immediately after recovery. The latter advantage permits calculation of clock drift essentially over the period that the unit is in the water. Previously, clock drift included the drift occurring prior to launch which, due to stability vs temperature characteristics of the oscillator, is higher at the higher temperatures.

3.3.2.3 Radio Direction-Finder. Each of the units retrieved during prime recovery operations was located by utilizing the radio direction-finder system. Consisting of a Bendix ADF receiver, an orthogonal DF loop antenna mounted forward of the bridge, and a TI-developed matching unit, this system was used for the first time during the MILROW experiment. The matching unit shifts the OBS beacon frequency (26.67 MHz) to 3.33 MHz which is within the normal tuning range of the Bendix ADF receiver (200 kHz to 4 MHz). Three balanced mixer units are driven by a common 30-MHz oscillator to translate the frequency of the sense antenna signal and two loop antenna signals while maintaining the original phase relationships. Balun transformers at the loop antenna base convert the balanced-loop outputs to single-ended signals as required by the mixer and permit the use of standard coaxial lead-in cables.

Equipment calibration was performed in Amchitka harbor; a transmitting OBS unit was placed on the dock and a DF bearing vs visual bearing chart made while the SEA SCOPE maneuvered in the harbor.

Performance of the system exceeded expectations. This is best illustrated by the recovery operations on station 5 which occurred at night; although the beacon light failed shortly after the unit surfaced, the SEA SCOPE was able to proceed directly to the exact unit location and recover the sphere.

3.3.2.4 Sonar Recall. The sonar-recall data have been examined due to the inordinate amount of time required to recall some of the units. Calculations were possible only for those units where the release time could be obtained from the tape film. (The amplifiers and tape recorder are shut off at the time of sonar release.) In performing these calculations, it was necessary to assume that the beacon transmitter started operating as soon as the unit surfaced. The 5-min digital-clock drift was considered when performing the calculations on station 7. Results of the examination are shown in Table III-6. Since the times required to surface are in good agreement with theoretical calculations at shallow depths, it was possible to extrapolate recall time for station 9, unit 22; the recall time was approximately 45 min.

Table III-6

SONAR-RECALL INFORMATION

Station	Unit	Water Depth (fm)	Sonar Recall Started	Unit Released	Time to Recall* (min)	Unit on Surface	Time to Surface* (min)	Theoretical Time to Surface** (min)
3	21	1814	10/17 0240Z	10/17 0241Z	1	10/17 0324Z	43	30
5	19	675	10/17 1211Z	10/17 1233Z	22	10/17 1245Z	12	11
6	27	470	10/18 2120Z	10/18 2134Z	14	10/18 2144Z	10	8
7	30	237	10/18 2345Z	10/19 0017Z	37	10/19 0023Z	6	4
8	26	770	10/16 1817Z	10/16 1848Z	31	10/16 1902Z	14	13

*Times have been rounded off to nearest minute.

**Ascent rate is estimated at 1 fm/sec. Times have been rounded off to nearest minute.

It is obvious from the table that the recall times at depths less than 1000 fm are excessive; this is attributed to two factors:

- Multipath arrivals distorting the incoming sonar signal so that the correct code is not received three times in succession
- Bottom area isonified by the sonar signal is reduced substantially at shallow depths

Unless present equipment and/or sonar coding techniques are changed, it does not appear possible to improve this situation. Further discussions of this problem are contained in subsection 3.6.

3.4 DERIGGING AND EQUIPMENT REFURBISHMENT

3.4.1 SHIP DERIGGING. The SEA SCOPE arrived at Stearns Wharf, Santa Barbara, California, on 11 November 1969; the vessel was derigged during the period 12-14 November. The operation was conducted in a routine manner, and no major problems were encountered. No attempt was made a this time to inventory the equipment; all equipment was crated immediately and shipped to Dallas.

3.4.2 EQUIPMENT REFURBISHMENT. Refurbishment and inventory efforts were initiated immediately after the equipment arrived in Dallas. (Failure analysis, discussed in subsection 3.4, was performed in conjunction with refurbishment.) The objective of these efforts was to place all equipment in good operating condition so that a future operation could be conducted with a minimum of lead time.

All of the OBS units were rotated through Anadite Inc. for repair and repainting of the spheres. (Failure analysis on those units which malfunctioned was completed before they were rotated.) Corrosion and paint damage was minimal on most of the spheres; the units which were dropped closest to Amchitka showed the most signs of corrosion. Spot grinding and alodining were sufficient to stop corrosion on the spheres used in the MILROW experiment. Damage to the spheres loaned to Lamont-Doherty Geological Observatory was more severe, and complete reanodizing was required.

The equipment repairs performed are listed below:

- Unit 16 (replaced four reactance amplifier boards and two trilevel amplifier boards)
- Unit 18 (replaced hydrophone crystals)
- Unit 20 (completely overhauled amplifiers; repaired one seismometer)
- Unit 22 (replaced tape-recorder drive motor)
- Unit 24 (completely overhauled and repaired amplifier boards and release wires; realigned seismometers; replaced hydrophone crystals)
- Unit 25 (repaired main wiring harness and digital clock)
- Unit 27 (replaced seismometer)
- Unit 30 (replaced seismometer)

No major repairs to the auxiliary equipment were necessary.

Upon completion of repainting, maintenance, and general cleaning, a thorough system test was performed on each unit. These tests were identical to those performed before the units were shipped to the field. Test tapes were recorded after the tests and carefully examined for evidence of abnormal operation. No unit was prepared for storage until proper system operation had been ascertained.

The last step prior to storing the equipment was discharging the silver zinc batteries. This was accomplished in accordance with the manufacturer's instructions and should extend the useful cell life by 6 months. All equipment was placed in storage at the TI Expressway Site on 12-13 February 1970.

3.4.3 INVENTORY. Coincident with the refurbishment effort, a complete inventory of all OBS equipment was performed. The objectives of the inventory program were to

- Compile a complete list of capital and residual items utilizing computerized inventory techniques
- Dispose of all equipment which was no longer useful to the contract, was damaged beyond repair, or would cost more to repair than to replace; this was done through the TI Contracts department in accordance with government procedures
- Package all equipment in containers suitable for field use, with subsystems and their spare parts packaged together

The inventory also identified areas in which the spares complement was deficient. Additional spares were ordered as the requirement was established. Certain items (e.g., the beacon-light assemblies) have lead times beyond completion of the refurbishment program. These items will be added to the inventory list and properly stored when received.

Figure III-9 is an example of the Inventory-Control Reports generated by the computer during the MILROW operation. These reports permit the program administrator to continuously monitor the purchase and disposition of parts required in field operations. Column headings are as follows:

- RP NO. and RP DATE — Number and date of request for purchase
- PO NO. and PO DATE — Number and date of purchase order
- VENDOR — Name of the vendor offering best price and delivery
- PART DESCRIPTION — Brief description of item to be purchased

RP NO.	RP DATE	PO NO.	PO DATE	VENODR	PART DESCRIPTION	CNO	QTY	COST EACH	COST TOTAL	BILL DATE	DELV FIELD	LOCAT NUM SEASC	CAP EXP	COND CODE	INV NO
2454	08/28/69	92879	08/28/69	SB OTTS	SPARES	119	1	4,000.00	4,000.00						
2454	08/29/69	92879	09/02/69	SB OTT'S	DUXSEAL	119	5	2.95	14.25		09/02	SEASC	E	N1	
2454	08/29/69	92879	09/02/69	SB OTT'S	PROTOPLIERS 243G	119	1	2.80	2.80		09/02	SEASC	E	N1	
2454	08/29/69	92879	09/02/69	SB OTT'S	1470 PROTOPLIERS	119	1	.78	.78		09/02	SEASC	E	N1	
2454	08/29/69	92879	09/02/69	SB OTT'S	710 ADJ WRENCH	119	1	3.25	3.25		09/02	SEASC	E	N1	
2454	08/29/69	92879	09/02/69	SB OTT'S	P634 SCREWDRIVER	119	1	.98	.98		09/02	SEASC	E	N1	
2454	08/29/69	92879	09/02/69	SB OTT'S	P573 SCREWDRIVER	119	1	.88	.88		09/02	SEASC	E	N1	
2454	08/29/69	92879	09/02/69	SB OTT'S	P506 SCREWDRIVER	119	1	.98	.98		09/02	SEASC	E	N1	
2454	08/29/69	92879	09/02/69	SB OTT'S	4 IN 1 SCREWDRIVER	119	1	2.95	2.95		09/02	SEASC	E	N1	
2454	08/29/69	92879	09/02/69	SB OTT'S	PR 290 MCR BOLT CUTTERS	119	1	19.52	19.52		09/02	SEASC	E	N1	
2454	08/28/69	92879	09/28/69	SB OTTS	BROTO SOCKET #5324	119	1	1.57	1.57		09/04	SEASC	E	N1	
2454	08/28/69	92879	08/28/69	SB OTTS	TARPAULIN 10X12	119	1	11.20	11.20		09/09	SEASC	E	N1	
2454	08/28/69	92879	08/28/69	SB OTTS	SINKERS,.LINE , 3 HOOKS	119	1	2.20	2.20		09/10	SEASC	E	N1	
2454	08/28/69	92879	08/28/69	SB OTTS	WIRE STRIPS	119	1	1.11	1.11		09/04	SEASC	E	N1	
2454	08/28/69	92879	08/28/69	SB OTTS	PERMATEX T-6	119	1	.45	.45		09/08	SEASC	E	N1	
2454	08/28/69	92879	08/28/69	SB OTTS	GLOVES	119	6	.77	4.62		09/08	SEASC	E	N1	
2454	08/28/69	92879	08/28/69	SB OTTS	RUBBER SLIPS 24 INCH	119	8	.88	7.04		09/06	SEASC	E	N1	
2454	08/28/69	92879	08/28/69	SB OTTS	RUBBER SLIPS 18 INCH	119	6	.64	3.84		09/06	SEASC	E	N1	
2454	08/28/69	92879	08/28/69	SB OTTS	LAMPS 100A	119	120	.20	24.00		09/06	SEASC	E	N1	
2454	08/28/69	92879	08/28/69	SB OTTS	PAPER TOWELS-HOLDER	119	1	1.08	1.08		09/05	SEASC	E	N1	
2454	08/28/69	92879	08/28/69	SB OTTS	RAGS	119	1	27.68	27.68		09/05	SEASC	E	N1	
2454	08/28/69	92879	08/28/69	SB OTTS	TELEPHONE CALLS-DELIVERY	119	1	3.62	3.62		09/05	SEASC	E	N1	
2454	08/28/69	92879	08/28/69	SB OTTS	RAGS	119	1	9.35	9.35		09/06	SEASC	E	N1	
2454	08/28/69	92879	08/28/69	SB OTTS	DUXSEAL	119	1	2.85	2.85		09/02	SEASC	E	N1	
2454	08/28/69	92879	08/28/69	SB OTTS	WATER PUMP GREASE 5 #	119	1	2.38	2.38		09/05	SEASC	E	N1	
2454	08/28/69	92879	08/28/69	SB OTTS	SCREWS	119	1	1.50	1.50		09/04	SEASC	E	N1	
2454	08/28/69	92879	08/28/69	SB OTTS	FITTINGS GREASE GUN	119	1	3.50	3.50		09/04	SEASC	E	N1	

Figure III-9. Inventory-Control Report Sample

- CNO — Charge number used to designate items purchased for particular phases of an operation
- QUANTITY, COST EACH, and COST TOTAL — Self-explanatory
- BILL DATE — Date when invoice is received
- DELV FIELD — Date of delivery to field crew
- LOCAT NOW — Present location of item
- CAP EXP — Designates whether the item is capital or expendable equipment
- COND CODE — Indicates whether the item is new (N1) or has been returned for repair (01)
- INV NO — Inventory number which is assigned if item is a capital purchase

While compiling the OBS inventory lists, full advantage was made of past experience in field operations. The final inventory sheets are generated by an RPG computer program developed specifically for OBS-type operations.

Complete inventory listings were distributed to those addresses indicated on the DD Form 1423.

3.4.4 SUMMARY. Refurbishment and inventory efforts placed the OBS equipment in a high state of operational readiness. At the time of storage, equipment condition was such that only routine testing and repair of those items specifically mentioned previously will be required prior to shipment to the field. New pinch-roller springs, which are included in the spares complement, can be installed during unit checkout. Lead time for obtaining a new crystal oscillator for clock 30 is currently estimated at 6 to 8 weeks. The spares complement is sufficient to conduct an operation similar in scope to the MILROW experiment. Useful life of the silver zinc cells should extend until September 1970 for the HR types and until March 1971 for the LR types.

3.5 RECOMMENDATIONS

The MILROW experiment was only marginally successful from the standpoint of field operations. As discussed in detail in earlier sections, 10 units were deployed, and eight were recovered. Although this recovery percentage is expected, based on previous OBS operations, it is felt that, with appropriate attention, this percentage could be improved.

More disappointing than the unit-recovery percentage is the amount of useful data obtained from the eight units recovered. This performance is directly attributable to two factors — human error and equipment malfunctions.

All aspects of the OBS field operation have been subjected to critical review and analysis. Resulting recommendations are offered which hopefully will provide a basis for decisions regarding the use of OBS units in future operations.

3.5.1 PERSONNEL RECOMMENDATIONS. The MILROW experiment was initiated after a long period of OBS inactivity. Due to the lack of continuity, nearly all of the personnel involved in previous experiments had been transferred to other groups within Texas Instruments and were not available for MILROW. Although a new field team had to be assembled on extremely short notice, TI was able to obtain a group of persons who are highly qualified in at-sea operations to conduct the experiment. However, the time element was so short that it was not possible to train and indoctrinate these persons in OBS operations to the degree desired. Thus, it is believed that the human errors experienced were minimal under the circumstances.

TI recommends that at least 2 weeks of additional preparation time be provided in future operations.

3.5.2 EQUIPMENT RECOMMENDATIONS. Most of the equipment malfunctions encountered during the MILROW operation were recurrent. Included in the following recommendations are modifications which would eliminate the causes of these malfunctions.

3.5.2.1 Tape Recorder. Difficulties associated with the tape recorder have historically contributed more heavily to the loss of data than any other single subsystem.

This unit was developed specifically for the OBS program at a time when no commercially available equipment could fulfill the mission requirements. Advances in tape-recorder technology — both in recording devices and in recording techniques — have been significant in recent years. It is recommended that a program be initiated to determine the optimum recording technique for the OBS program under existing state-of-the-art conditions and to determine what equipment is available which will reliably meet the recording requirements.

Replacement of the tape recorders would be an expensive operation. If funding would not permit replacement, it is considered essential that the radio beacon transmitter be relocated from its present position at the inside top of the sphere. On several occasions, the tape-recorder takeup reel has bound against this unit causing the tape to be deposited in the bottom of the sphere. With a minimum amount of time and effort, the transmitter could be conveniently relocated near the bias oscillator.

3.5.2.2 Release Mechanism. Redundancy in the release system exists only in that any one of the three devices can actuate the single release mechanism. In all cases, current must pass through the external release wires and burn the fuse wire before release is accomplished. It is recommended that a study be performed to develop a release system which is truly redundant.

One possibility is a device combining the hinge mechanism presently used on one side of the sphere with the release mechanism used on the other side of the sphere. This device could then be used on both sides, and actuation of either release mechanism would release the unit. A second possibility is to incorporate a separate explosive release which would disengage the present release mechanism.

3.5.2.3 Acoustic Transponder. During the early phases of the MILROW program, it was suggested that acoustic transponders be installed on the OBS units. Subsequent investigation into the possible applications of such devices has strengthened the argument that they be added to the OBS subsystem complement.

The most simple and straightforward application of the transponder would be to determine the presence of an OBS unit on the bottom. After repeated attempts to recall a unit are unsuccessful, the question always arises as to whether or not the unit surfaced prematurely and drifted away undetected. Since there is presently no way to resolve this question, lengthy periods are spent attempting sonar recall, and extensive search patterns are run at the clock-release times. Interrogation of the transponder would eliminate much of the guesswork associated with present recall procedures and could result in a significant reduction in operating costs. For example, the digital clocks and backup clocks are usually programmed for release a week to 10 days after sonar recall is attempted. When a unit does not respond to sonar recall, the ship and her crew must remain in the operations area for possible clock release. However, if the unit did not respond to sonar recall and could not be contacted via the transponder, the decision not to await clock release could logically be made.

A second application of the transponder would be to more accurately determine the unit's bottom location. By interrogating the transponder, the ship could be positioned directly over the unit and a fix obtained at that location. There is presently no way to determine how far from the launch location a unit drifts during descent to the bottom. This knowledge would also be a distinct advantage during sonar-recall operations.

The most advantageous application would be to use the transponder to relay subsystem status information from the unit to the ship while the unit is on the bottom. Several passes over each station could be made during the recording period and the unit recalled at any indication of equipment failure. At the same time, a distinct improvement in timing accuracy could be realized by having the transponder annotate the tape whenever it is interrogated. By accurately controlling the start of interrogation transmission aboard ship and calculating traveltime through the water, it would be possible to relate the time of tape annotation to GCT.

3.5.3.4 Sonar Recall. As discussed in subsection 3.4, the time to accomplish sonar recall in depths less than 1000 fm is excessive. If future operations in shallow water are contemplated, it is suggested that the use of an omnidirectional recall transducer and modification of the sonar-recall-coding philosophy be investigated. It is believed that utilization of a different coding technique would decrease the required time to recall and also decrease the probability of a unit being recalled by a code other than its own (e.g., unit 29, station 10).

3.5.2.5 Search and Recovery Equipment. Search and recovery operations could be simplified by adding a radar reflector to the OBS unit. Failure of the beacon transmitter during daytime recovery or failure of the beacon light during nighttime recovery can result in a lengthy search to find the unit. A radar reflector would provide an effective method for locating the unit if either or both of the present subsystems malfunction.

3.5.2.6 Power Supplies. At present, the B1000 battery pack supplies power to the radio beacon and to the release mechanism. If the pressure switch on the radio beacon malfunctions, the unit transmits during the entire on-bottom period or until the battery voltage falls below tolerance. In either case, it is unlikely that sufficient power is available to burn the fuse wire during sonar recall or digital-clock recall. (Backup-clock recall uses a separate power supply.) It is recommended that a separate power supply be provided for the release mechanism. This would not necessarily require the addition of more batteries; it may be possible to reallocate the power distribution of existing batteries to meet this need.

3.5.3 SUMMARY. The preceding recommendations can be divided according to complexity and amount of effort required. Relocation of the beacon transmitter and addition of the acoustic transponder in its simplest form require very little, if any, design work and could be accomplished with a very modest effort. However, these modifications should be accomplished prior to the next OBS deployment program, as opposed to making the modifications during preparations for a field operation.

The other recommendations are such that an engineering study is suggested to determine the best technique for achieving the desired results. The recommendation that a separate power supply be provided for the release mechanism has been included in the latter classification, since it is believed that an examination of the entire battery complement is in order.

SECTION IV

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2. Texas Instruments Incorporated, 1968: Final Analysis Report, Aleutian Islands Experiment — Ocean-Bottom Seismographic Experiments, Contract F33657-67-C-1341, 31 July.

3. Texas Instruments Incorporated, 1968: Preliminary Analysis Report, Aleutian Islands Experiment — Ocean-Bottom Seismographic Experiments, Contract F33657-67-C-1341, 31 Jan.

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APPENDIX A

PRELIMINARY BULLETIN

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APPENDIX A
PRELIMINARY BULLETIN

This preliminary bulletin was produced from data recorded by four OBS units near the Aleutian island of Amchitka between 26 September and 17 October 1969. Included are arrival times, phase types and periods, ground displacement, epicenter-to-station distances, and azimuth. Events were hand-associated with all epicenters located by the USC&GS. All of the USC&GS events used were within 50° and had magnitudes of ≤ 6.1. There were approximately 250 earthquakes including events not reported by the USC&GS but seen by a minimum of three OBS stations.

Routine analysis was utilized using the film seismograms made from the field tapes. The phase data were punched on cards and processed through a computer program to convert the arrival times (clock time) to Greenwich Civil Time (GCT) and to correct the times for tape-recorder head misalignment and clock drift. All phase data are presented in chronological order, with the hypocenter data placed before the first associated arrival. Figure A-1 shows the bulletin analysis flow chart.

The bulletin data are presented in two sections — epicenter data and phase data. A page from the bulletin is shown in Table A-1. The phase data are listed either as associated station events or as unassociated station events where USC&GS origin times were reported to the nearest minute only.

1. USC&GS Epicenter Data

The first line of the epicenter data contains date (GCT), origin time (GCT), latitude, and longitude. Depth, H (km) is found in the second line.

Table A-1

SAMPLE PAGE FROM PRELIMINARY BULLETIN

DAY	STA	PHASE	C	TIME	AMP	PER	DIST	AZI
26 SEPT	02 18 07.5		50.96N	178.20W				
				H = 0 KM				
26 SEPT	S6	EP	Z	2 18 40.8			1.88	297
		ES	X	19 4.4			1.88	297
26 SEPT	11 25 17.6		60.12N	152.99W				
				H = 97 KM				
26 SEPT	S8	EP	P	11 29 18.0			17.63	252
26 SEPT	S6	EP	Z	11 29 19.6	161.0	0.4	17.59	254
26 SEPT	19 36 00.5		51.49N	178.54E				
				H = 25 KM				
26 SEPT	S8	EP	P	19 36 4.9			0.67	100
		ES	X	13.8			0.67	100
26 SEPT	S6	EP	P	19 36 16.8			0.46	49
		ES	X	29.3			0.46	49
26 SEPT	20 49 06.0		52.91N	166.99W				
				H = 32 KM				
26 SEPT	S6	EP	P	20 51 10.0			8.59	268
		E	X	17.9			8.59	268
		E	X	25.2			8.59	268
27 SEPT	01 42 51.6		50.86N	179.24W				
				H = 25 KM				
27 SEPT	S8	+IP	Z	1 43 8.6	92.4	0.1	0.90	305
		ES	X	21.3			0.90	305
27 SEPT	S6	EP	Z	1 43 15.7			1.40	313
		E	P	16.8			1.40	313
		E(S)	X	36.4			1.40	313

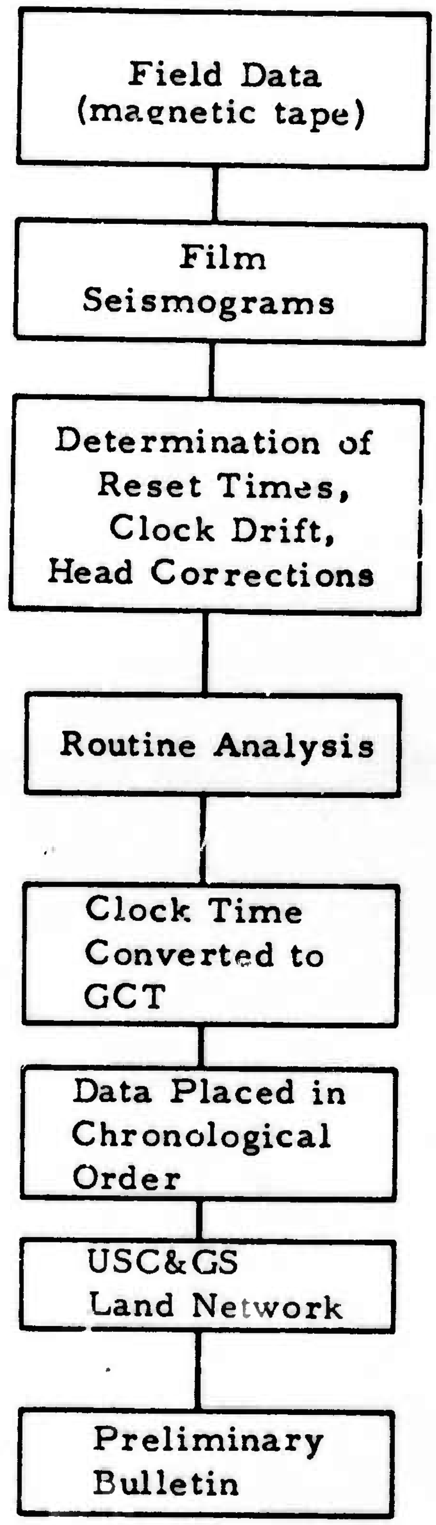


Figure A-1. Bulletin Analysis Flow Chart

2. Phase Data

The column heading appearing at the top of each page of the bulletin applies to phase data. The headings are defined as follows:

- DAY — day and month on which the arrival occurred (GCT); they are listed only when the station designation changes number.
- STA — station designation.
- PHASE — type of phase recorded at the station; prefixes are defined as follows:
  - — I preceding the phase type indicates an impulsive and sharply defined phase beginning; + (up) or - (down) indicates direction of first motion
  - — E preceding the phase type indicates an emergent phase motion
  - — I or E alone indicates an unidentified phase arrival
  - — Parentheses enclosing phase type indicate a phase identification which is suspect
- C — component on which the phase arrival was observed and measured; designated by
  - — Z (vertical seismometer)
  - — X (first horizontal seismometer)
  - — Y (second horizontal seismometer)
  - — P (pressure transducer)
- TIME — Phase arrival time (GCT); arrival times are measured to nearest tenth of a second on all components
- AMP — phase amplitude (one-half peak to peak) in millimicrons or microns of ground displacement. Amplitudes have been corrected for instrument response and are presented to the nearest tenth of a unit; those presented in microns are followed by a μ after the tenths column. Amplitudes are measured from the largest pulse in the first few cycles when possible; those reported as 999.9 indicates that the trace was overdriven. (Amplitude responses of the instruments are shown in Figure A-2)

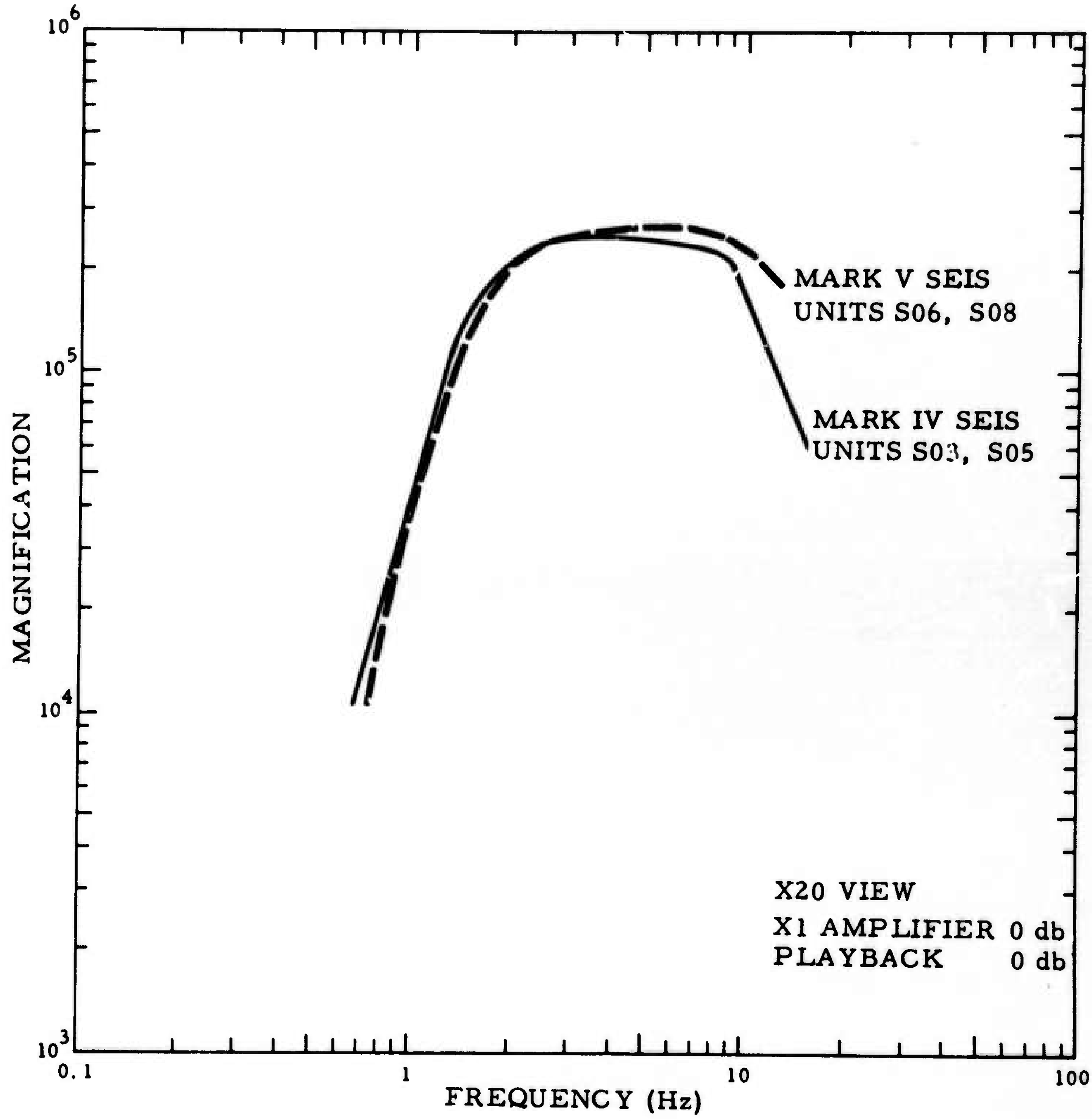
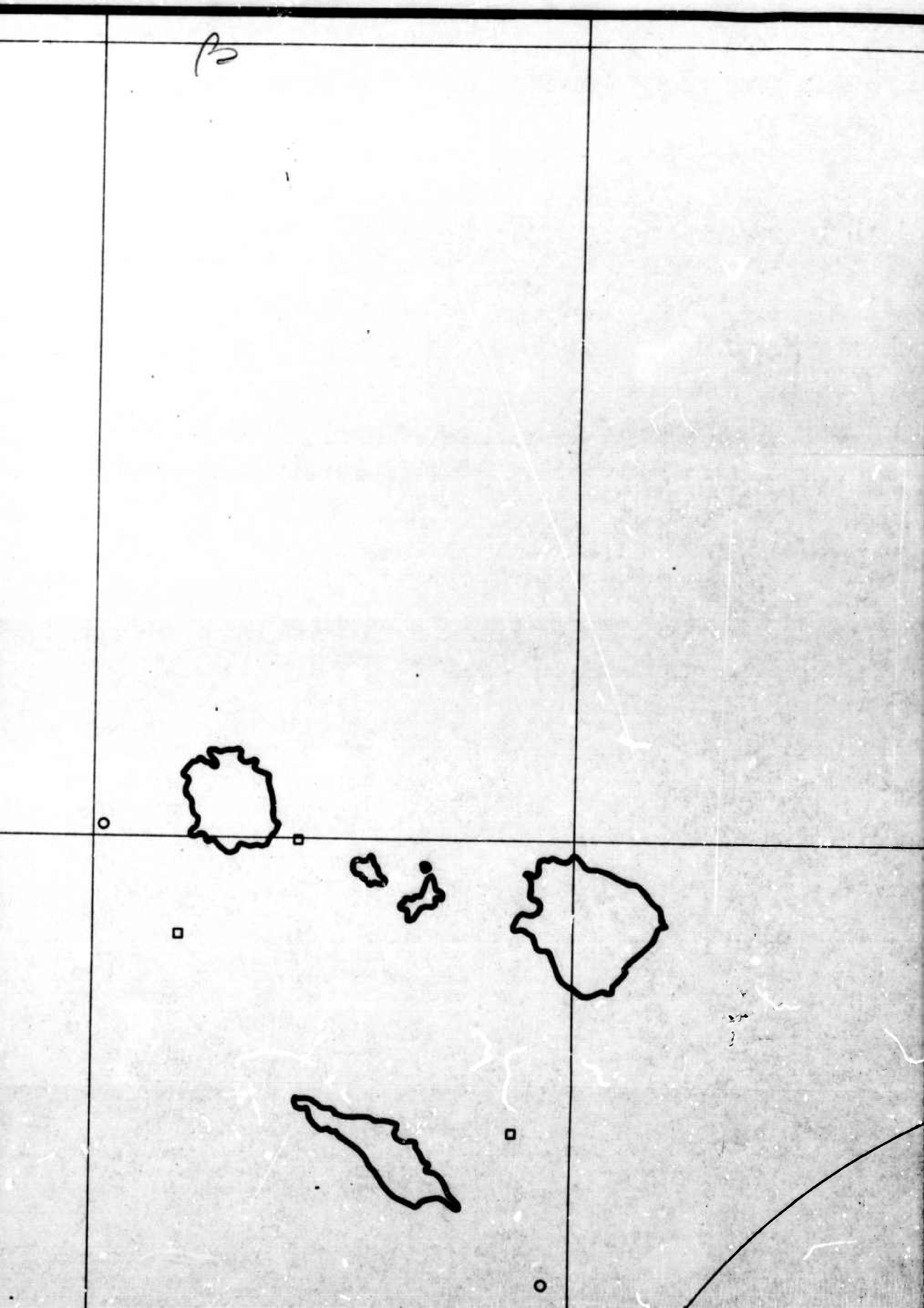
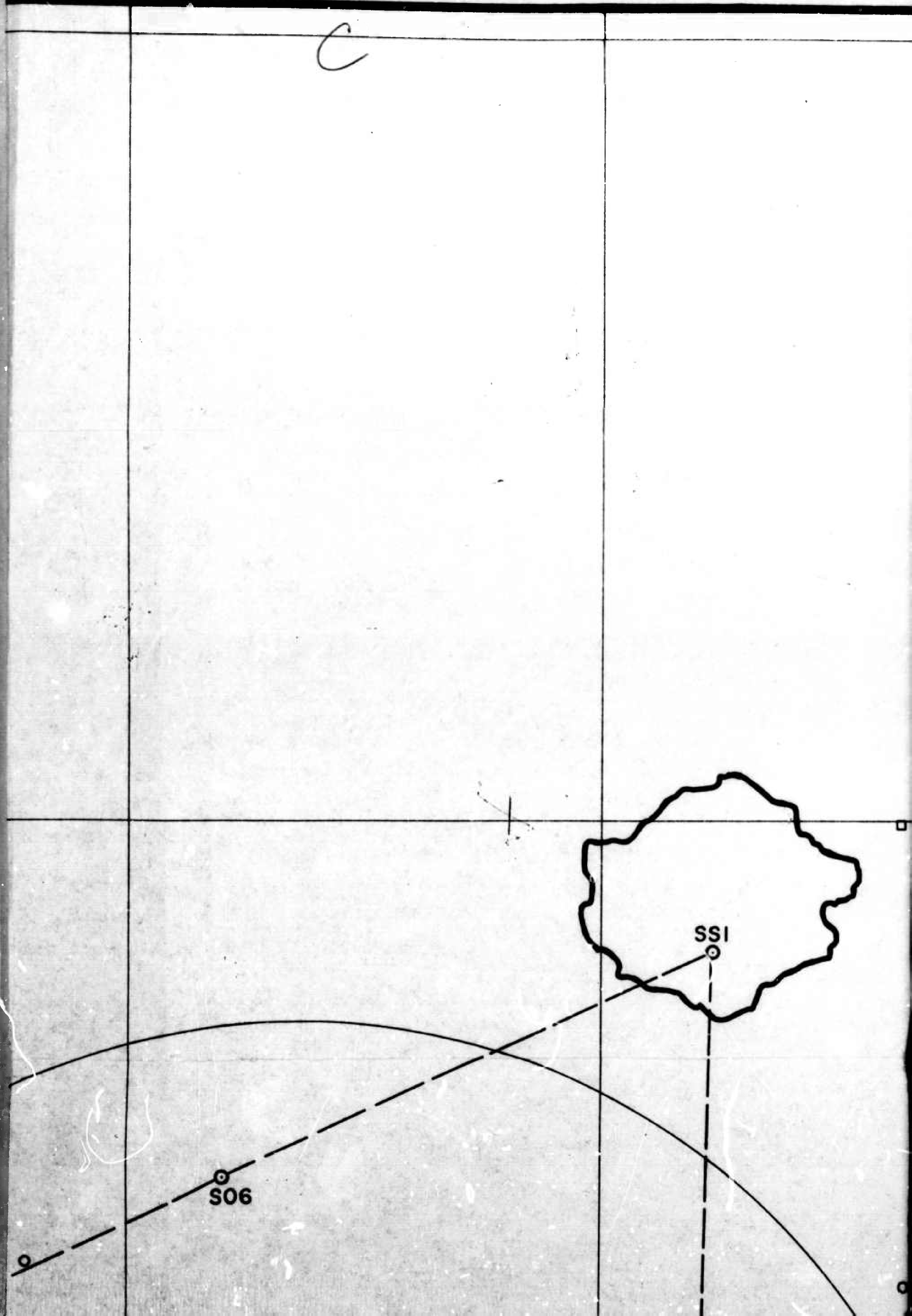


Figure A-2. Ocean-Bottom Seismograph System Response

- PER — period of the phase in seconds measured from the largest pulse in the first few cycles; those with amplitudes reported as 999.9 do not contain period measurements
- DIST — distance from epicenter location to recording station; all distances are computed using geocentric coordinates and are reported to the nearest hundredth of a degree
- AZI — epicenter-to-station azimuth; all are clockwise from north and are reported to the nearest degree


A

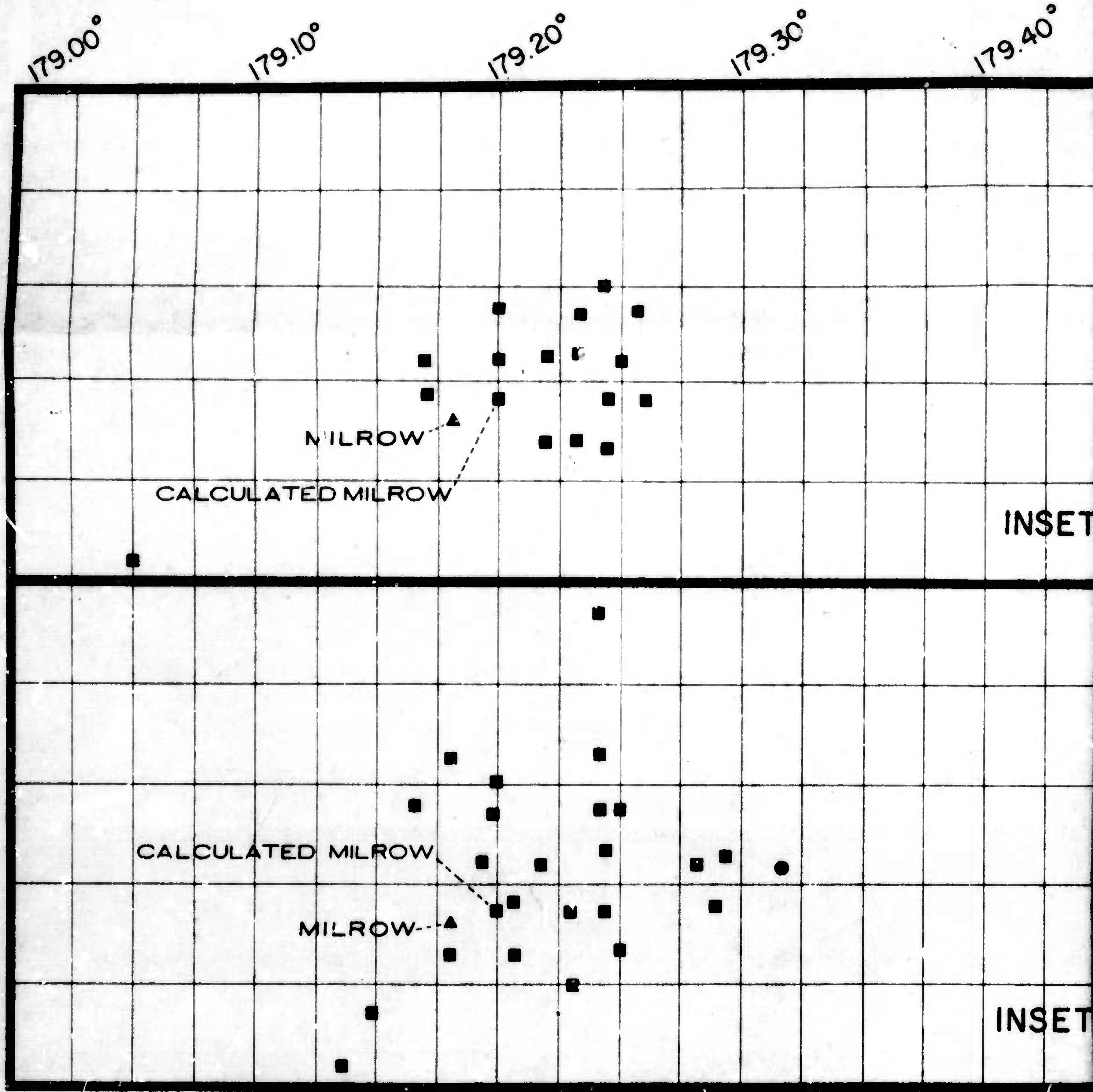

B


C
SS1
S06

D

52°

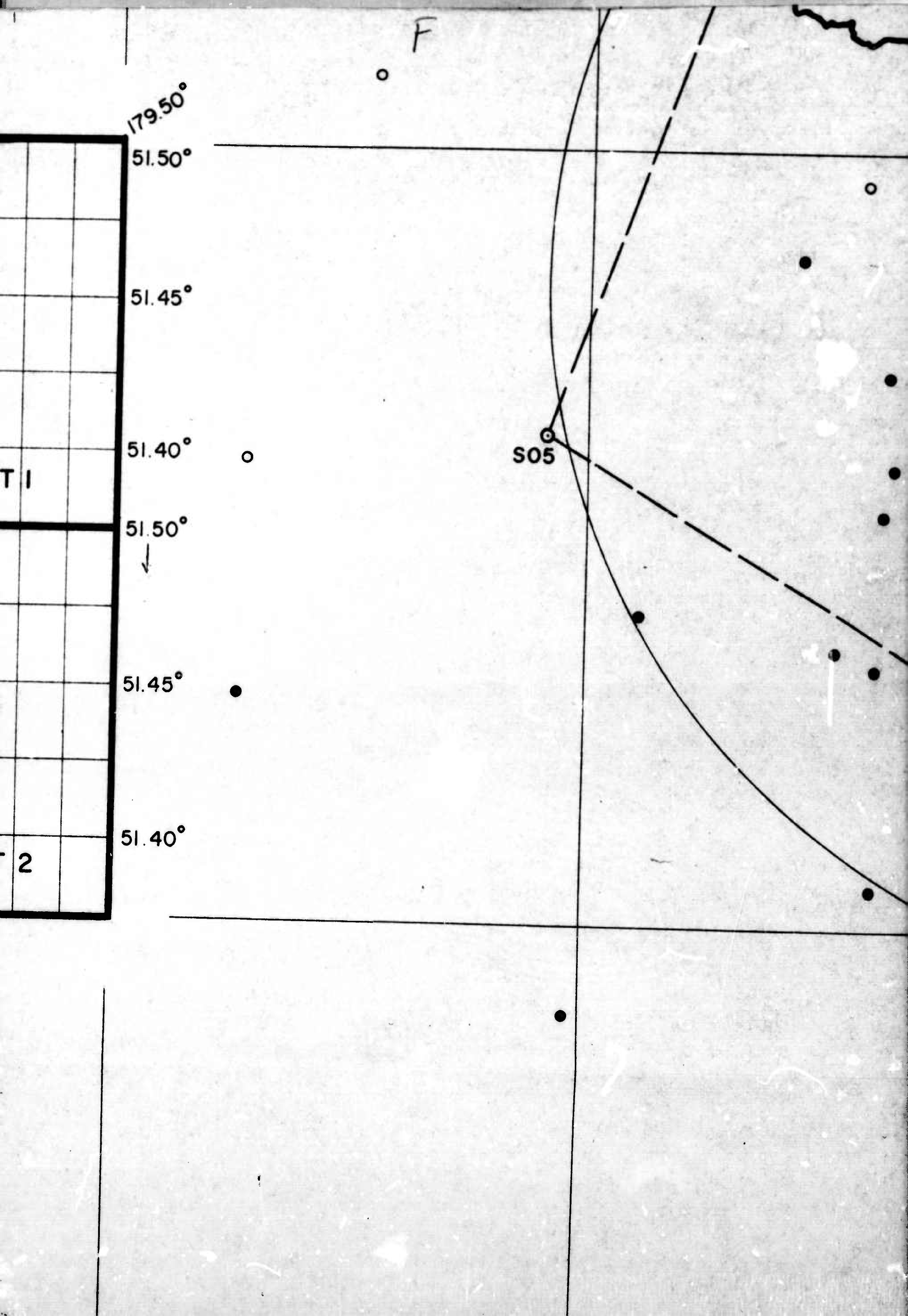
E

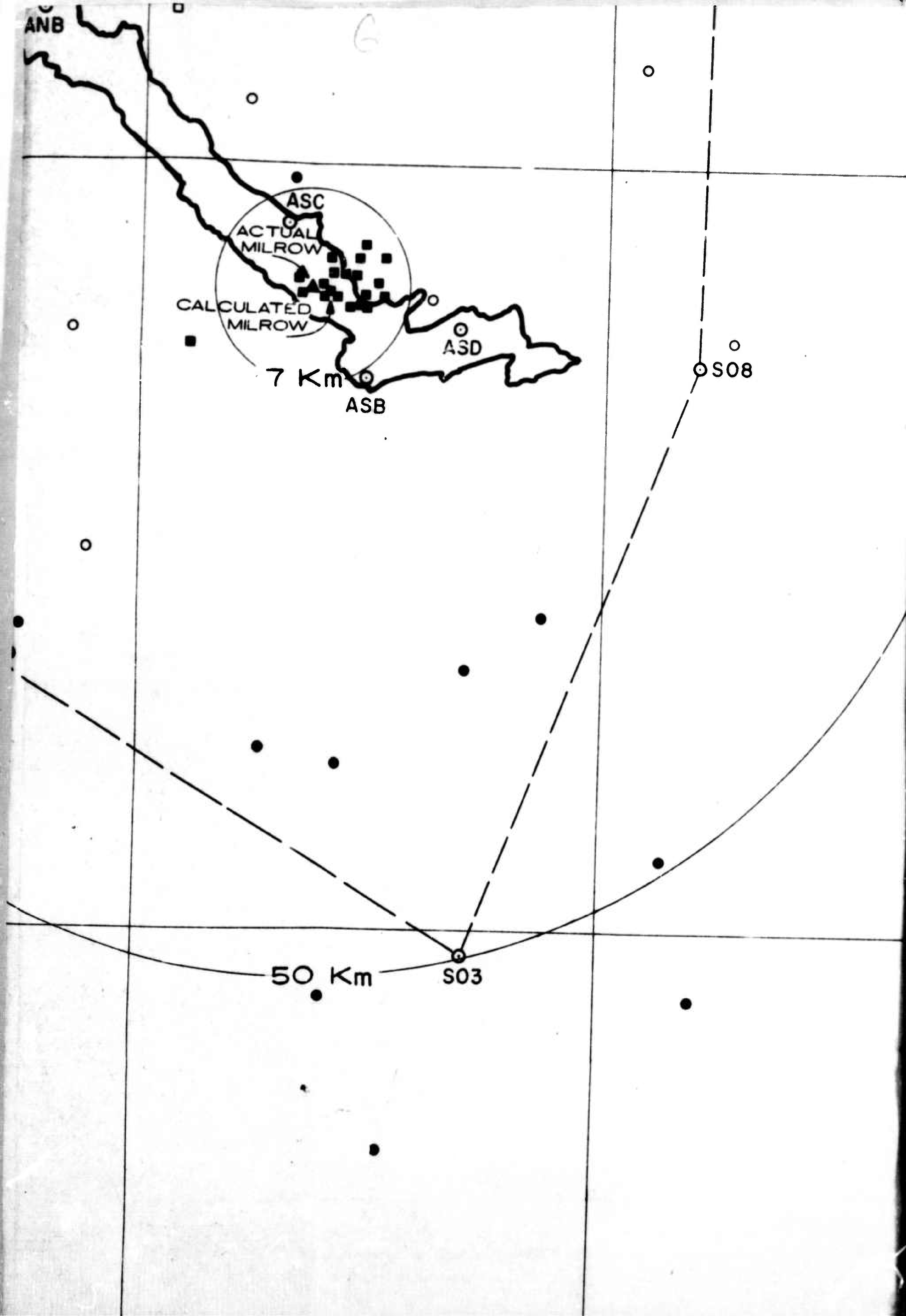


EXPANDED SCALE

INSET 1 – NEAR-MILROW HYPOCENTERS CALCULATED WITHOUT RESIDUAL CORRECTIONS

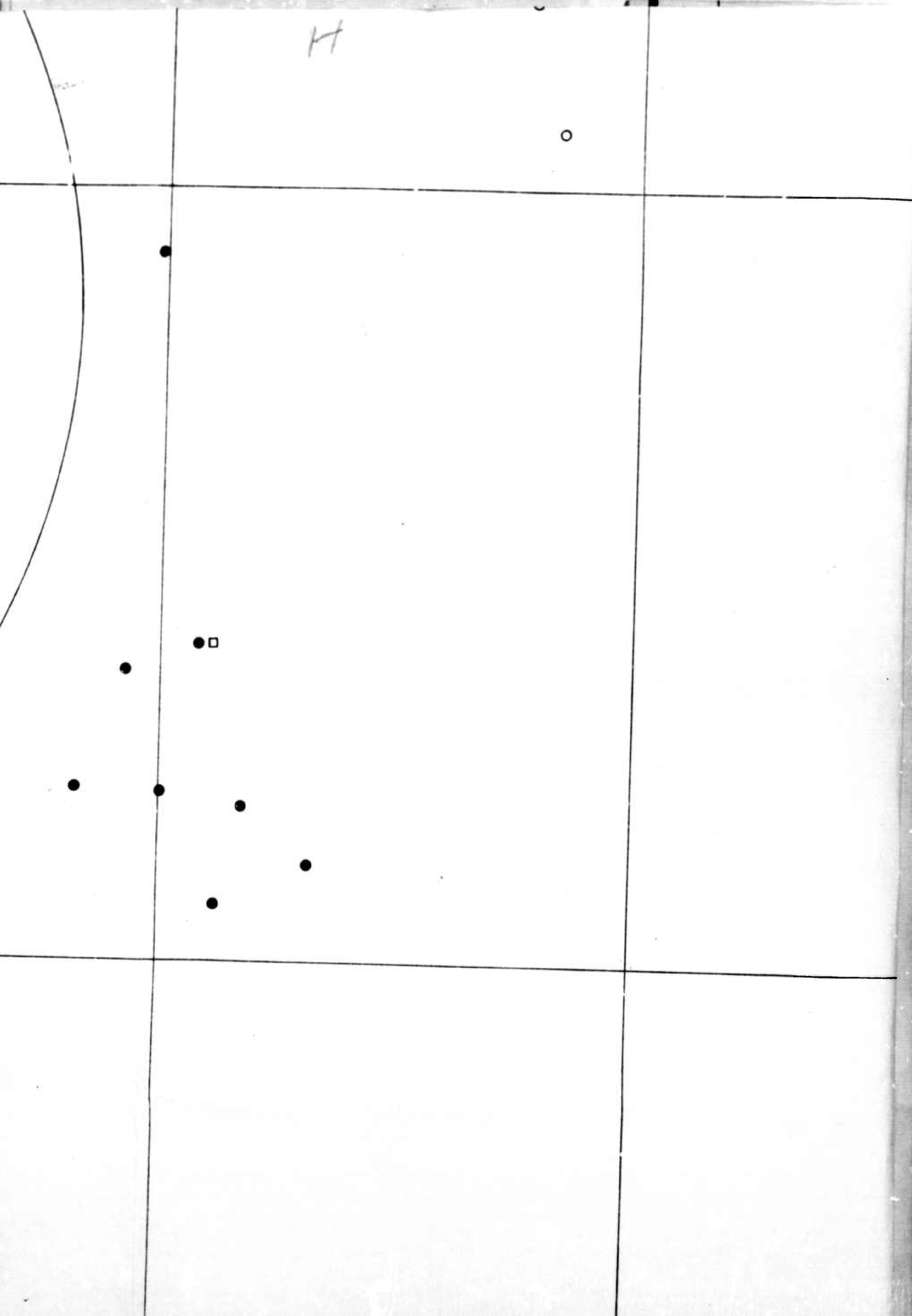
INSET 2 – NEAR-MILROW HYPOCENTERS CALCULATED USING MILROW RESIDUAL CORRECTIONS

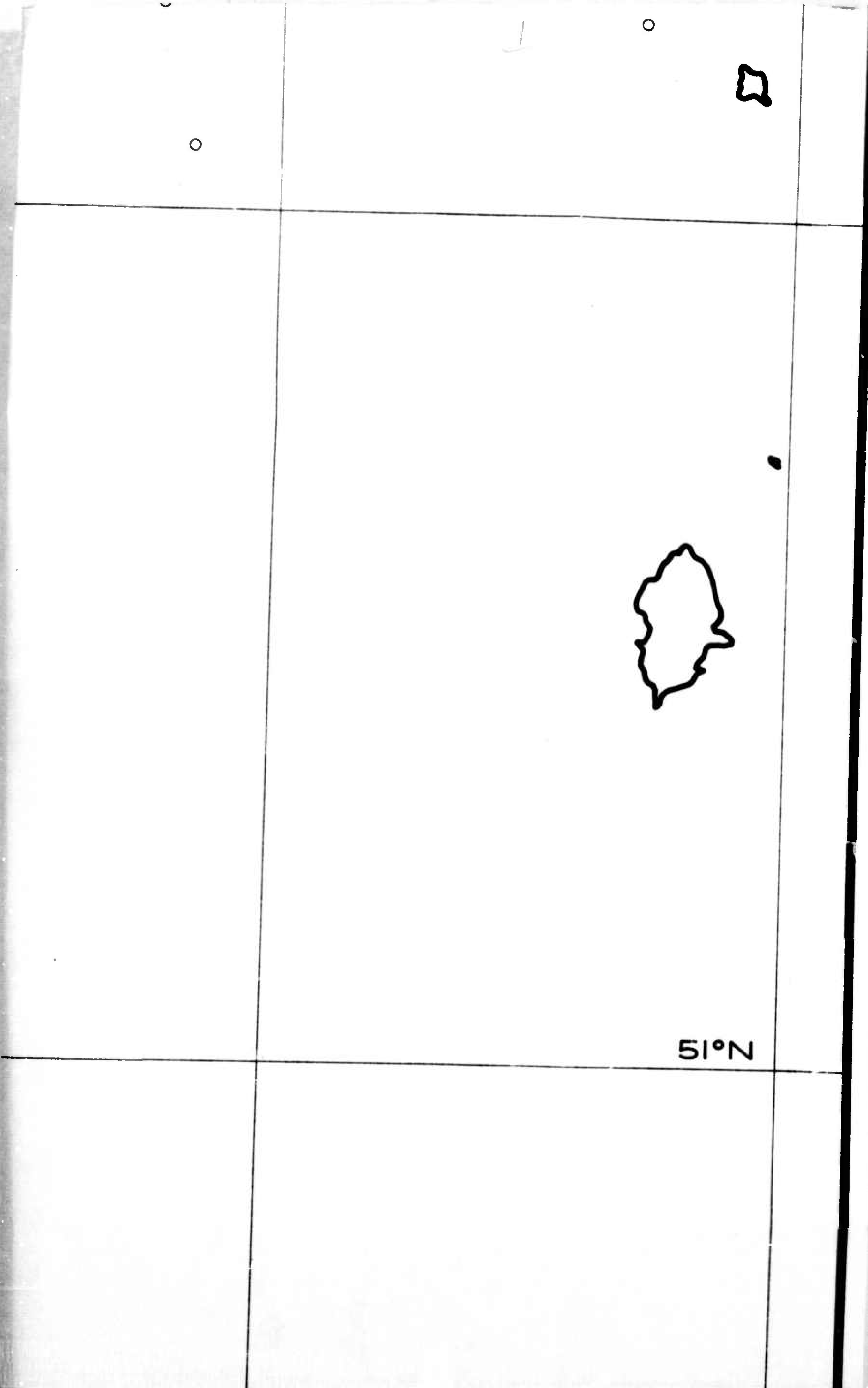

F
179.50°
51.50°
51.45°
51.40°
T 1
51.50°
51.45°
51.40°
2
S05

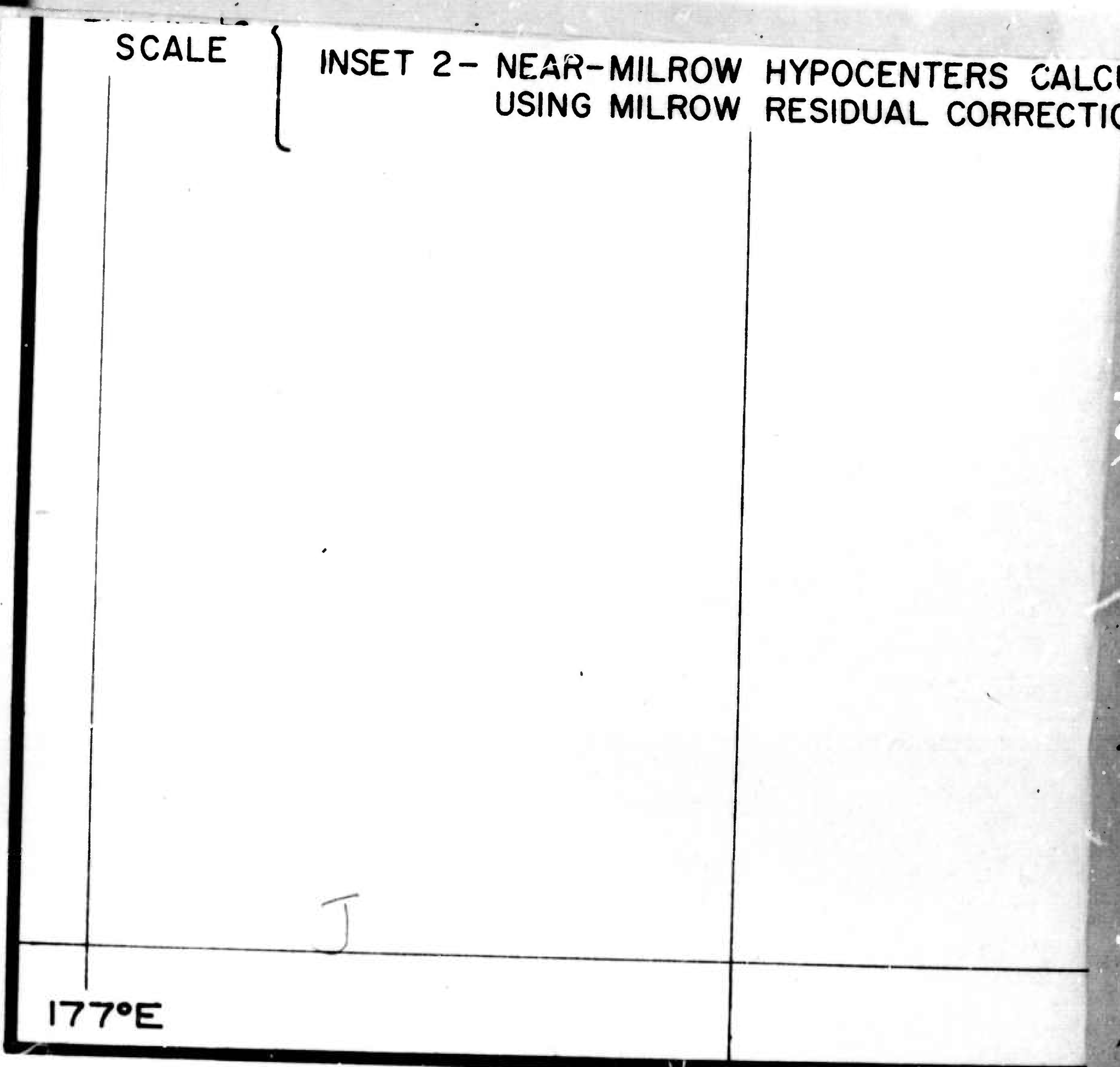


ANB
G
ASC
ACTUAL
MILROW
CALCULATED
MILROW
ASD
7 Km
ASB
S08
50 Km
S03

H

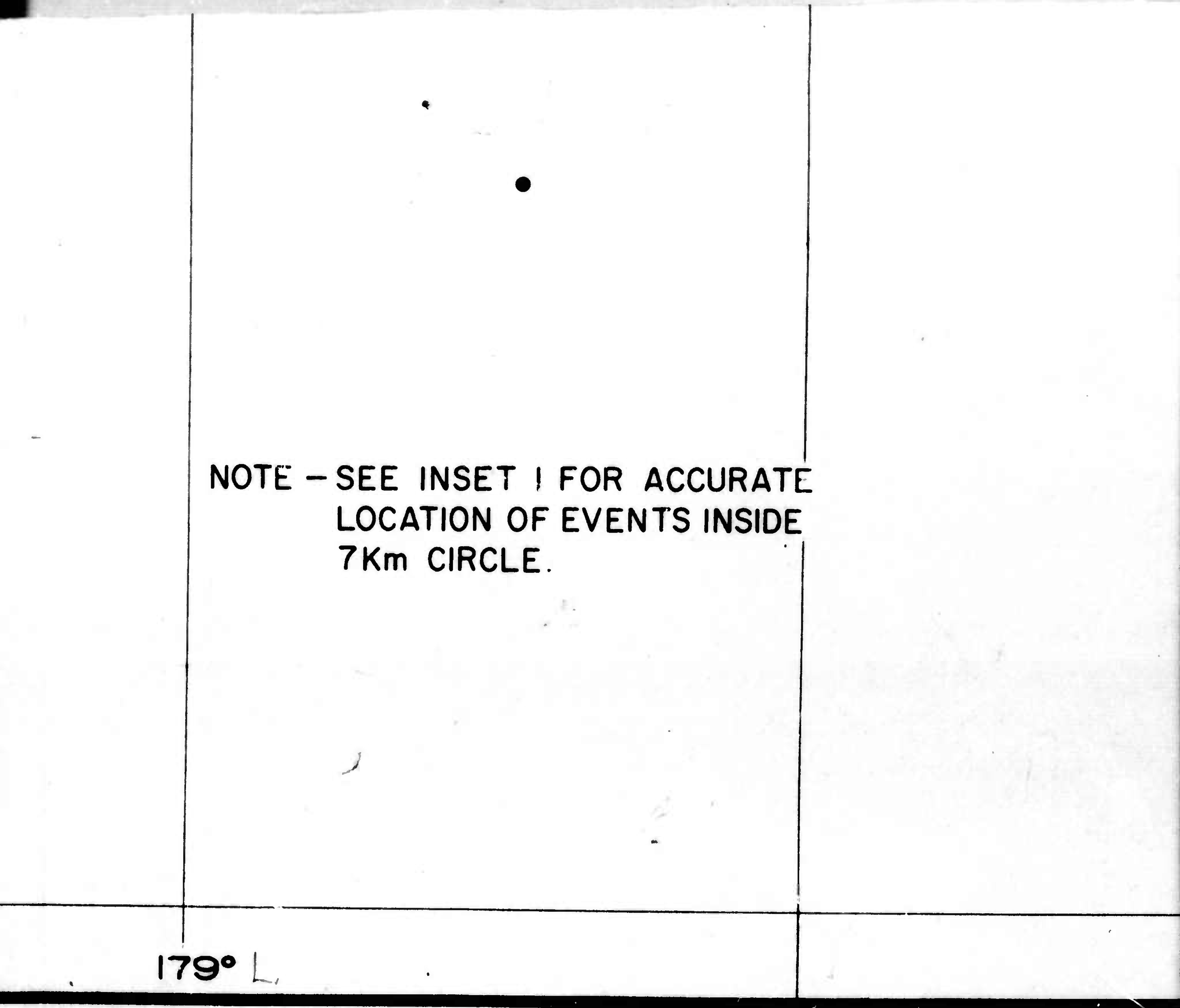


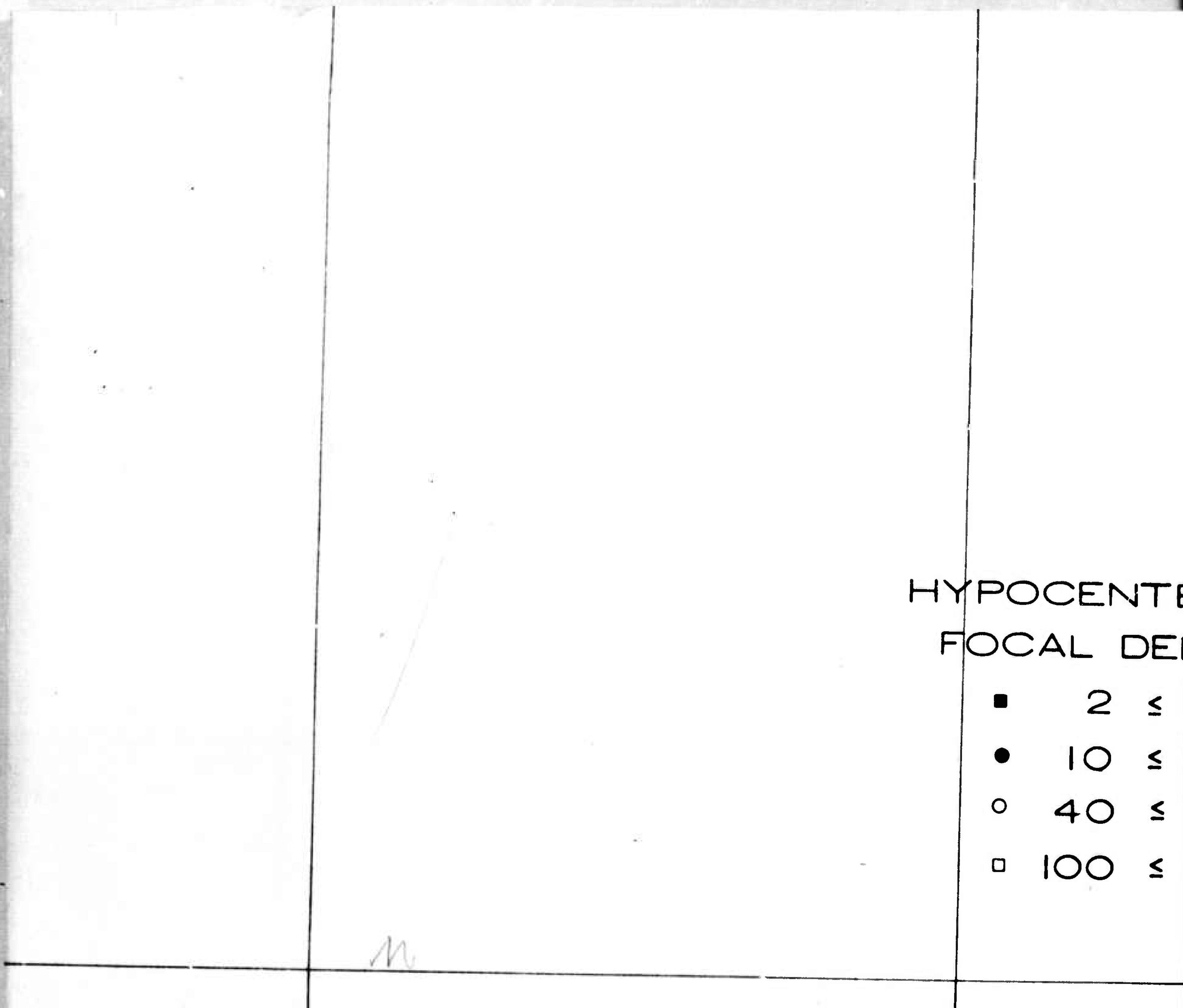

51°N


SCALE
INSET 2- NEAR-MILROW HYPOCENTERS CALCU
USING MILROW RESIDUAL CORRECTIO
177°E

ULATED
ONS

178°


NOTE – SEE INSET 1 FOR ACCURATE
LOCATION OF EVENTS INSIDE
7Km CIRCLE.
179°



FIGUR

HYPOCENTER LOCATION
FOCAL DEPTH LEGEND

■ $2 \leq h < 10$ Km
● $10 \leq h < 40$ Km
○ $40 \leq h < 100$ Km
□ $100 \leq h < 160$ Km

FIGURE II-17

179°W

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13. ABSTRACT

The VELA Seismological Center, upon request from the Advanced Research Projects Agency of the Department of Defense, participated in Project MILROW, an underground nuclear explosion triggered 2 October 1969 at 2206Z on Amchitka Island in the Aleutian Chain. Texas Instruments was selected to install, operate, and analyze data from a network of Ocean-Bottom Seismograph units deployed in waters surrounding Amchitka Island for a 3-week period. The objectives of this program were to observe aftershock activity and to improve epicenter locations of such seismic activity within a 50-km radius of the MILROW site. The major tasks involved in completing the experiment included equipment preparation, field operations, and data analysis. This report describes the experiments, analytical goals, and the results obtained. Evaluation of the OBS equipment and recommendations for improving equipment reliability are also included. A crustal model was developed to permit hypocenter calculations for events in the vicinity of Amchitka Island; 250 associated events which correlated with USC&GS data were found. Hypocenter-location refinement was attempted on 140 of these events; 81 events yielded satisfactory hypocenter location, and 27 of the events occurred in the vicinity of ground zero.

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P and S waves						
Seismograph						
Seismogram						
Field operations						
Experiment preparation						
Failure analysis						
Equipment evaluation						
Recommendations						